

NONSURGICAL PERIODONTAL THERAPY

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Abstract Healing events following nonsurgical periodontal therapy in patients with periodontal pockets up to 12 mm deep were investigated. Incisors, cuspids and premolars in 49 patients and 2532 surfaces were treated by a combined therapy of oral hygiene instruction and supra- and subgingival debridement. The results were monitored by recordings of plaque, bleeding on probing, probing pocket depth and probing attachment level at 6 sites of each tooth every 3rd month during 24 months. The results demonstrated that a gradual and marked improvement of the periodontal conditions took place during the initial 6-9 months following start of therapy. During the remaining observation period no further changes of the recorded parameters were noted. The therapy appeared equally effective in deep as in moderately deep pockets. No differences in results could be observed between debridements using hand or ultrasonic instruments, and between a single instrumentation versus repeated instrumentations. Differences between patients and surfaces treated by 7 participating operators were negligible. Studies focusing on non-responding sites showed that 7 different patterns of probing attachment change over time could be identified in these sites. A linear pattern of gradual loss of probing attachment was found for the majority of the non-responding sites. Of the less frequently seen patterns, 3 approximated a linear course and 3 were non-linear. Probing attachment loss was more frequently noticed for sites with an initial probing pocket depth ≤ 3.5 mm than for sites initially ≥ 7.0 mm. Sites with probing attachment loss were somewhat more frequent among sites with high scores for plaque, bleeding, suppuration and residual probing depth than in sites with low scores. However, the diagnostic reliability of these clinical recordings to disclose attachment loss was low.			
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Preface

This thesis is based on the following papers, which will be referred to in the text by their Roman numerals.

I. Badersten, A., Nilvéus, R. & Egelberg, J. (1984) Effect of nonsurgical periodontal therapy. II. Severely advanced periodontitis. *Journal of Clinical Periodontology* 11, 63-76.

II. Badersten, A., Nilvéus, R. & Egelberg, J. (1984) Effect of nonsurgical periodontal therapy. III. Single versus repeated instrumentation. *Journal of Clinical Periodontology* 11, 114-124.

III. Badersten, A., Nilvéus, R. & Egelberg, J. (1984) Effect of nonsurgical periodontal therapy. IV. Operator variability. *Journal of Clinical Periodontology*. In press.

IV. Badersten, A., Nilvéus, R. & Egelberg, J. (1984) Effect of nonsurgical periodontal therapy. V. Patterns of probing attachment loss in non-responding sites. *Journal of Clinical Periodontology*. In press.

V. Badersten, A., Nilvéus, R. & Egelberg, J. (1984) Effect of nonsurgical periodontal therapy. VI. Localization of sites with probing attachment loss. *Journal of Clinical Periodontology*. In press.

VI. Badersten, A., Nilvéus, R. & Egelberg, J. (1984) Effect of nonsurgical periodontal therapy. VII. Bleeding, suppuration and probing depth in sites with probing attachment loss. *Journal of Clinical Periodontology*. In press.

Abstract

Healing events following nonsurgical periodontal therapy in patients with periodontal pockets up to 12 mm deep were investigated. Incisors, cuspids and premolars in 49 patients and 2532 surfaces were treated by a combined therapy of oral hygiene instruction and supra- and subgingival debridement. The results were monitored by recordings of plaque, bleeding on probing, probing pocket depth and probing attachment level at 6 sites of each tooth every 3rd month during 24 months.

The results demonstrated that a gradual and marked improvement of the periodontal conditions took place during the initial 6-9 months following start of therapy. During the remaining observation period no further changes of the recorded parameters were noted. The therapy appeared equally effective in deep as in moderately deep pockets. No differences in results could be observed between debridements using hand or ultrasonic instruments, and between a single instrumentation versus repeated instrumentations. Differences between patients and surfaces treated by 7 participating operators were negligible. Studies focusing on non-responding sites showed that 7 different patterns of probing attachment change over time could be identified in these sites. A linear pattern of gradual loss of probing attachment was found for the majority of the non-responding sites. Of the less frequently seen patterns, 3 approximated a linear course and 3 were non-linear. Probing attachment loss was more frequently noticed for sites with an initial probing pocket depth ≤ 3.5 mm than for sites initially ≥ 7.0 mm. Sites with probing attachment loss were somewhat more frequent among sites with high scores for plaque, bleeding, suppuration and residual probing depth than in sites with low scores. However, the diagnostic reliability of these clinical recordings to disclose attachment loss was low.



Introduction

EFFECT OF ORAL HYGIENE PROCEDURES AND SUPRA- AND SUBGINGIVAL SCALING AND ROOT PLANING

Successful results of nonsurgical periodontal therapy can be obtained in periodontal pockets (Tagge et al. 1975, Waite 1976, Hughes & Caffesse 1978, Torfason et al. 1979, Morrison et al. 1980, Badersten et al. 1981, Hill et al. 1981, Caton et al. 1982, Lindhe et al. 1982a, b, Proye et al. 1982, Cercek et al. 1983, Echeverria & Caffesse 1983, Pihlstrom et al. 1983). The short-term effect of this conservative therapy for pockets of different initial probing depths have been reported by Morrison et al. (1980). Improvements of probing pocket depth and probing attachment level were observed 1 month following the start of therapy. Deeper sites improved more than shallow sites. Torfason et al. (1979) observed a gradual improvement of bleeding scores and probing pocket depths over an experimental period of 8 weeks in sites initially 5 to 7 mm deep. Helldén et al. (1979) and Listgarten et al. (1978) found that pockets averaging 5.4 mm (Helldén's data) and 7.0 mm (Listgarten's data) in depth initially, were reduced to 4.1 and 5.3 mm, respectively, after 8 weeks. After 25 weeks these pockets were reduced to 3.6 mm and 4.8 mm, respectively.

The prolonged effect of plaque control and repeated supra- and subgingival debridement in patients with moderately advanced periodontitis was studied by Badersten et al. (1981). Incisors, cuspids and premolars with periodontal pockets 4 to 7 mm deep were treated. Bleeding scores, probing pocket depths and probing attachment levels improved during the first 4 to 5 months after start of therapy. Little change occurred during the rest of the 13-month observation period. Probing pocket depths decreased in all pockets irrespective of initial pocket depth by a combination of gingival recession and improved probing attachment levels. More gingival recession and probing attachment gain was observed for sites with deeper initial probing pocket depth than for shallower sites. Probing pocket depths of 4.5 mm or less decreased by

0.3 to 1.6 mm; deeper sites (4.5 to 7.5 mm) decreased by 2.1 to 3.3 mm. Pockets with initial probing depths of 2.0 to 3.5 mm demonstrated a slight loss of probing attachment, while pockets initially 7.0 to 7.5 mm gained from 1.1 to 1.5 mm in probing attachment.

Pronounced reduction in probing pocket depth and gain in probing attachment in initially deep sites and slight loss of attachment in shallow sites after conservative therapy has also been reported by Hill et al. (1981), Lindhe et al. (1982a, b), Cercek et al. (1983) and Pihlstrom et al. (1983). Furthermore, Hill et al. (1981), Lindhe et al. (1982a, b) and Pihlstrom et al. (1983) found that the results can be maintained during several years in patients provided dental prophylaxes 3 to 4 times a year.

METHOD OF INSTRUMENTATION

The immediate goal of subgingival debridement is to remove dental plaque, calculus and contaminated cementum from the root surface. After removal of exogenous deposits, it is recommended to plane the root surface smooth in order to facilitate home care and reduce the adherence of new deposits.

Studies comparing hand and ultrasonic instruments in smoothing root surfaces are contradictory. Stende & Schaffer (1961), Björn & Lindhe (1962), Allen & Rhoads (1963), Belting & Spjut (1964), Kerry (1967), Wilkinson & Maybury (1973), Rosenberg & Ash (1974), Van Volkinburg et al. (1976) and Meyer & Lie (1977) found that smoother surfaces were produced with hand instruments than with ultrasonics. Root surfaces after use of ultrasonic instruments were characterized as stippled (Belting & Spjut 1964) or showed depressions and irregular ridges (Wilkinson & Maybury 1973). Meyer & Lie (1977) observed that ultrasonic instruments produced smeared or knotted patterns and left smooth areas alternating with defects or wounds in the surface. However, Jones et al. (1972) and Pameijer et al. (1972) found relatively little difference in smoothness comparing the two types of instruments. Ewen (1966) and Ewen & Gwinnett (1977) found that smoother surfaces were produced by ultrasonic than by hand instruments. Ewen & Gwinnett (1977) observed that hand instruments often produced a haphazard, irregular pattern of grooves in the root surface, particularly when vertical and horizontal strokes were combined. Differences in surface topography were dependent upon the sharpness of the instrument and the number of strokes involved.

These results may be contradictory because of different methods of evaluation or as a result of differences in application of the instrument to the root

surface rather than differences between the instruments. Differences in operating techniques, sharpness of the tips, pressure used and time spent on each surface may produce contradictory results. For ultrasonic instruments, surface roughness and irregularities increase with use of higher pressure during instrumentation and with higher power settings (Björn & Lindhe 1962, Allen & Rhoades 1963, Clark et al. 1969).

Lie & Meyer (1977) and Nishimine & O'Leary (1979) concluded that hand instruments removed calculus more effectively than ultrasonic instruments. However, Stende & Schaffer (1961), Moskow & Bressman (1964), Jones et al. (1972) and Wilkinson & Maybury (1973) found that both types of instruments were effective in calculus removal.

Hatfield & Baumhammers (1971) and Aleo et al. (1974, 1975) suggest that cementum exposed to periodontal pockets may be cytotoxic as a result of contamination by endotoxins. Removal of such contaminated cementum should be a major aim of root planing (Aleo et al. 1974, 1975, Jones & O'Leary 1978, Dally et al. 1979, Nishimine & O'Leary 1979). Differences between hand and ultrasonic instruments in removing cementum have been reported. Moskow & Bressman (1964) found that more cementum remained after debridement with ultrasonic instruments than with hand instruments. Nishimine & O'Leary (1979) observed that endotoxin was more effectively removed with hand than with ultrasonic instruments. These findings together with the observation that ultrasonic instruments may be less efficient in producing a smooth root surface have led to the recommendation that planing with hand instruments should be carried out subsequent to the subgingival use of ultrasonic instruments (Suppipat 1974). Van Volkinburg et al. (1976) and O'Leary & Kafrawy (1983) indicate that total cementum removal is not a realistic clinical objective. Jones & O'Leary (1978) concluded, however, that root planing with hand instruments rendered diseased root surfaces almost as free of endotoxin as uninvolved, healthy root surfaces.

The importance of subgingival surface roughness or cementum removal for the healing of periodontal tissues is unclear. In patients with gingivitis and a mean initial probing pocket depth of 2.0 mm, Donzé et al. (1973) observed that reductions in gingival fluid and sulcus depth were the same, regardless whether hand or ultrasonic instruments were used. Ringle (1967) reported no differences between the two methods of treatment in reduction of proximal pockets initially 4 to 6 mm. Torfason et al. (1979) observed reductions in the frequency of bleeding on probing and probing pocket depth following oral hygiene instruction and hand or ultrasonic debridement in pockets initially

4 to 6 mm deep and found no differences between the two instrumentation modalities.

In the above clinical trials, the observation periods were limited to 1 to 2 months. Badersten et al. (1981) found no differences in the response following repeated hand or ultrasonic debridements of pockets initially 4 to 7 mm deep over 13 months.

FREQUENCY OF INSTRUMENTATION

In several studies of nonsurgical periodontal therapy, multiple appointments for instrumentation have been used (Listgarten et al. 1978, Torfason et al. 1979, Slots et al. 1979, Morrison et al. 1980, Badersten et al. 1981, Hill et al. 1981, Lindhe et al. 1982a, b, Pihlstrom et al. 1983). Lindhe et al. (1982a) and Pihlstrom et al. (1983) expressed the opinion that subgingival scaling and root planing are technically demanding and should be repeated to ensure complete removal of calculus, bacteria and other contaminants from the teeth. Waerhaug (1978a, b) concluded that plaque and calculus in deeper pockets can not be completely removed by subgingival scaling. Slots et al. (1979) observed microbial repopulation of root planed sites after 2 to 6 months. Mousquès et al. (1980) found that subgingival spirochetes returned to pretreatment proportions 6 weeks following a single session of scaling and root planing. Magnusson et al. (1984) similarly observed that subgingival spirochetes were dramatically reduced one week after subgingival instrumentation, and found a gradual return to baseline levels after 2 months in the absence of improved plaque control. Therefore, controlled oral hygiene and regularly repeated debridements following initial therapy have been considered important (Lindhe & Nyman 1975, Nyman & Lindhe 1979, Knowles et al. 1980, Axelsson & Lindhe 1981a, b). However, in a 9-month follow-up by Cercek et al. (1983), a single episode of ultrasonic debridement resulted in marked improvements in bleeding scores, probing pocket depths and probing attachment levels. The improvements were most pronounced in sites initially ≥ 6 mm deep and recurrence of disease was not detected. MacAlpine et al. (1984) and Braatz et al. (1984) reported that, apart from gradual improvements in clinical measurements, spirochete levels in deep sites (≥ 6 mm) dropped significantly following a single episode of ultrasonic instrumentation and remained low throughout the 6-month experiments. These studies indicate that a single debridement and longer periods between dental prophylaxes may be feasible.

OPERATOR VARIABILITY

The effectiveness of subgingival scaling and root planing may be related to operator skill. Torfason et al. (1979) found no differences after 2 months in the results obtained by 4 different operators. Badersten et al. (1981) found similar results after 13 months for 2 operators, both following use of hand and ultrasonic instruments. However, these studies were performed in patients with limited pocket depth.

PERIODONTAL PROBING MEASUREMENTS TO EVALUATE HEALING

In previous studies, the results of therapy have usually been evaluated from means of recorded measurements. Such means are valuable in determining the overall results. However, the means give little indication of the results for individual sites. In spite of the fact that the majority of deep pockets respond with gain of attachment following nonsurgical therapy, some specific sites seem to demonstrate loss (Badersten et al. 1981). Appropriate identification of such sites with probing attachment loss is important in order to determine the limitations of the treatment procedure and to assess the need for supplementary procedures.

Information on the errors of probing measurements is crucial for an adequate interpretation of results of therapy. Investigations of the validity of periodontal probing have revealed the limitations of the probe tip to locate the connective tissue attachment level. Listgarten (1972) pointed out that the extent of tissue penetration might be related to a variety of factors such as thickness of the probe, contour of the tooth surface and degree of gingival inflammation. Recent studies have shown that in inflammation, the probe tip generally penetrates beyond the apical termination of the junctional epithelium and into the subjacent connective tissue. In more healthy conditions, the probe tip usually stops short of the connective tissue attachment level. The penetration of the probe tip also varies with the probing force used (Robinson & Vitek 1979, Listgarten 1980, Magnusson & Listgarten 1980, Caton et al. 1981, Jansen et al. 1981, van der Velden & Jansen 1981, Fowler et al. 1982, van der Velden 1982, Warner & Sims 1982).

Accordingly, before therapy, in the presence of inflammation, the probe tip generally penetrates beyond the apical termination of the junctional epithelium and into the subjacent connective tissue. Therefore, it seems reasonable to assume that a more apical position of the probe tip after therapy is

associated with loss of connective tissue attachment. Data on sites that do not respond to therapy, but continue to lose probing attachment may reflect a significant underlying change in connective tissue attachment level. Thus, analysis of the response of individual sites, focusing on probing attachment loss, may indicate a true underlying deterioration of connective tissue support. Improved probing attachment levels after therapy, on the other hand, do not seem to be associated with a corresponding gain of connective tissue attachment but with improved tissue tonus and better adaptation of the junctional epithelium to the root surface (Fowler et al. 1982).

The interpretation of periodontal probing is not only complicated by the limitation of the probe tip in disclosing the connective tissue attachment level, but also by the degree of variability of repeated probing measurements. Studies on the reproducibility of probing pocket depth and probing attachment level measurements have shown that the difference between duplicate recordings may occasionally be as much as 2 mm or more. However, the vast majority of recordings can be reproduced with no more difference than 1 mm (Glavind & Löe 1967, Badersten et al. 1981, Cercek et al. 1983, Badersten et al. 1984). The reproducibility of duplicate recordings may vary by patient, tooth type, tooth surface and by pocket depth (Glavind & Löe 1967, Löe et al. 1978, van der Velden & de Vries 1980, Goodson et al. 1982, Haffajee et al. 1983b, Badersten et al. 1984). Therefore, in order to determine whether an individual site has lost attachment, the probing reproducibility for that site needs to be considered. Analysis of regression of a series of longitudinal probing attachment measurements for individual sites, as suggested by Goodson et al. (1982), seems to meet this requirement.

Usually, periodontal patients are subjected to a period of initial nonsurgical therapy, consisting of oral hygiene instruction and supra- and subgingival debridement. Reevaluation at the end of this phase is performed to determine the need for supplementary surgical therapy. For diagnosis at reevaluation, bleeding upon probing, suppuration upon probing and residual probing depth are used. The results of Haffajee et al. (1983a), however, seem to question the diagnostic reliability of these criteria. They monitored untreated patients every 2nd month during 1 year and found that none of the criteria studied was a reliable predictor of loss of probing attachment. They concluded that although these criteria may provide information about the extent of previous disease and the current condition of the tissues, they cannot be used as predictors of destructive disease activity.

Purpose of investigations

Periodontal lesions of different magnitude can be substantially improved with a combined therapy of oral hygiene instruction and supra- and subgingival debridement. The method of debridement, the frequency of debridement and the impact of operator variability may be less critical for the subsequent healing response than previously thought. These variables need to be investigated further, particularly with regard to the depth of the initial lesions and the results after long-term follow-up.

In spite of the fact that the majority of deep pockets respond with gain of probing attachment following nonsurgical periodontal therapy some individual sites seem to demonstrate a loss. Appropriate identification of such sites with probing attachment loss is important to determine the limitations of the treatment procedure and to assess the need for supplementary therapy.

Bleeding upon probing, suppuration, and probing pocket depth are clinical signs used to diagnose periodontal disease and to evaluate the need for and the results of periodontal therapy. Further evaluation of the usefulness of these criteria to disclose periodontal disease activity seems desirable.

The specific aims of the present studies were:

to evaluate, for 24 months, the response to nonsurgical periodontal therapy of patients with severely advanced periodontitis;

to compare the results obtained by hand and ultrasonic instruments;

to compare the results obtained by a single initial instrumentation and repeated instrumentations;

to evaluate the effect of operator variability;

to identify sites with probing attachment loss following nonsurgical periodontal therapy and to study the localization of these sites;

to evaluate to what extent bleeding on probing, suppuration, and probing pocket depth indicate lack of response to nonsurgical therapy as demonstrated by continuing loss of probing attachment.

Material and methods

The material for the present series of investigations originated from 3 separate studies (*Papers I, II and III*). 49 patients, 28-64 years of age, 34 males and 15 females, with severely advanced periodontal disease, were selected. Incisors, cuspids and premolars in either the maxilla or the mandible were studied. A minimum of 4 and a maximum of 10 teeth were used in each patient. The areas of the dentition under study had generalized periodontal destruction involving right and left sides of the jaw to a similar extent. Clinical signs of gingival inflammation and periodontal pockets ≥ 5 mm deep with calculus and bleeding upon probing were present on 2 or more aspects of each tooth.

ORAL HYGIENE INSTRUCTION

Initial oral hygiene instruction of the patients was provided by dental hygienists, using 2-3 visits during the first month of experimentation. Multi-tufted soft toothbrushes, single tufted toothbrushes, interdental brushes, triangular toothpicks and disclosing wafers were used. These aids were recommended for the patients as needed. Additional instruction and reinforcement as well as polishing of the teeth was provided according to individual needs throughout the 24 months duration of the studies.

DEBRIDEMENT OF PERIODONTAL POCKETS

In *Paper I*, the instrumentation of the periodontal pockets of the 16 patients was performed by 2 operators (author J.E. = operator 1 and author R.N. = operator 2). The operators treated 8 patients each. A split mouth approach was used to compare the effect of hand and ultrasonic instrumentation. The teeth of the right and the left sides of the jaw were randomly assigned for hand or ultrasonic instrumentation. The hand instruments were selected according to the preference of each operator. A Dentsply® -

Cavitron® Model 600 unit with TF1-10 tips was used for ultrasonic instrumentation (Cavitron Ultrasonics Inc., Long Island City, NY, USA). The debridement was performed under local anesthesia. The instrumentation was carried out until the operator felt confident that the root surfaces were adequately debrided and planed.

The first debridement was carried out during 1 visit 3 months after start of experimentation. Repeated instrumentation was performed at 6 and 9 months. Each operator made his own evaluation of the need of repeated instrumentation. The same type of instruments were used for the same teeth as before.

In *Paper II*, the instrumentation of the 13 patients was performed by 1 operator using ultrasonic instruments (author J.E. = operator 1). The debridement was started immediately following the initial examination. A split mouth approach was used to compare the effect of a single initial instrumentation to 3 instrumentations. The teeth of the right and the left sides of the jaw were randomly assigned for 1 or 3 instrumentations. The repeated instrumentation in 1 side of the jaw was carried out after 3 and 6 months. In other aspects, details were similar to those in *Paper I*.

In *Paper III*, a single episode of instrumentation was performed in 20 patients by a periodontist (author R.N. = operator 2) or by 1 of a group of 5 dental hygienists (operators 3 through 7). A split mouth approach was used to compare the results obtained by the participating therapists. Operator 2 was assigned at random to debride the teeth in 1 side of the jaw; 1 of the other operators was assigned to debride the teeth in the other half. Operators 3 through 7 treated 2 to 5 patients each. Hand and/or ultrasonic instruments were used according to individual operator preference. The instrumentation was performed immediately following the initial examination. In other aspects, details were similar to those in *Paper I*.

METHODS OF MEASUREMENT

The results of the treatment were evaluated by measurements of dental plaque, bleeding on probing, probing pocket depth, probing attachment level, and gingival recession. Recordings were made at the initial examination and subsequently every 3rd month throughout the 24 months by 1 examiner (author A.B.) who was unaware of which therapy had been used for the different teeth. At each examination, the bleeding scores were first taken, then the plaque scores followed by the measurements of probing pocket depth and probing attachment level. Recordings were made at 6 aspects of each tooth: mesiobuccal,

midbuccal, distobuccal, mesiolingual, midlingual and distolingual.

Bleeding on probing, probing pocket depth and probing attachment level were determined with an electronic, pressure sensitive probe (Electronic Periodontal Probe, Model 200, Vine Valley Research, Middlesex, NY, USA) in 33 subjects (*Papers II and III*). The probing force was standardized to 0.75 N. In the remaining 16 subjects, a standardized probing force was not used (*Paper I*). Probing pocket depth and probing attachment level measurements were taken to the nearest of 0.5 mm. A probe tip, 0.5 mm in diameter and calibrated in 1-mm increments, was used. The margins of soft acrylic onlays provided reference points for the attachment level measurements (Drufosoft, Dreve, Unna, West Germany).

The location of the gingival margin was assessed by subtraction of the figure for pocket depth from the figure for attachment level (gingival recession).

Suppuration on probing was recorded at 18 and 24 months. A droplet of pus visible either after the probing for bleeding examination or after the subsequent probeings for pocket depth and attachment level yielded as a positive score.

Presence of subgingival root furrows, concavities and furcation involvements on proximal root surfaces was recorded at the end of the studies by 2 independent examiners (authors A.B. and R.N.). The records of the 2 examiners were compared. Surfaces, scored positive by only 1 of the examiners were re-examined jointly by both examiners. A final decision as to presence or absence of root furrow, concavity and degree of furcation involvement was made. Grade I furcation involvement was scored, when a furcation aperture could be identified by probing. Grade II involvement was scored, when the furcation could be probed horizontally. Grade III, through- and through involvement, was not identified in any tooth under study.

Presence of proximal intraosseous defects was recorded from initial periapical, long cone radiographs. The vertical depth of the defects was measured to the nearest mm from the radiographic bone crest to a point along the root surface, where a periodontal ligament of even radiographic width could be observed. Again, when the measurements of the 2 independent examiners differed, a joint decision was made.

ANALYSIS OF PATTERNS OF PROBING ATTACHMENT LOSS IN NON-RESPONDING SITES

Patterns of probing attachment loss were studied in sites that had been

treated by plaque control and 1 single episode of supra- and subgingival instrumentation and monitored for 24 months (subjects from *Papers II and III*). From the available sites, "non-responding" sites, defined as sites showing loss of probing attachment amounting to 1.0 mm or more at 24 months as compared to baseline, were selected. Scatter diagrams of the sequence of 9 probing attachment recordings, obtained during the 24 months of study at 3-month intervals, were produced for each of these sites. The scatter diagrams were first surveyed jointly by 2 investigators (authors A.B. and J.E.), who agreed, that 7 different patterns of probing attachment level change over time could be identified. Subsequently, the diagrams were studied independently by the 2 investigators and the pattern for each of the sites was determined by each investigator. Classification of the sites was achieved by acceptance of concordant findings and by joint agreement at reexamination of those sites, for which the 2 investigators had initially designated different patterns (*Paper IV*).

IDENTIFICATION OF SITES WITH PROBING ATTACHMENT LOSS

The recordings at 3-month intervals during the observation period of 24 months providing a series of 9 probing attachment level measurements for each site were subjected to linear analysis of regression (Goodson et al. 1982). The slope of the regression line for each site was calculated as well as the projected probing attachment loss during the 24-month interval (Δy). The probability for each slope being different from a horizontal line was determined using 7 degrees of freedom. From the calculated values of Δy and probability, 2 groups of sites with probing attachment loss were identified based upon the following criteria: 1) Sites with $\Delta y > 1.5$ mm and $p < 0.05$; 2) Sites with $\Delta y > 1.0$ mm and $p < 0.05$ (*Papers V and VI*).

LOCALIZATION OF SITES WITH PROBING ATTACHMENT LOSS

The localization of sites with probing attachment loss was studied in all the available subjects from *Papers I, II and III*. The recordings were subjected to linear regression analysis as described above. The distribution of the 2 groups of sites identified as having probing attachment loss was studied with respect to patient, tooth type, tooth surface, initial probing pocket depth, presence of root concavity, furrow, furcation involvement, and intraosseous defect (*Paper V*).

DETERMINATION OF DIAGNOSTIC SENSITIVITY AND PREDICTABILITY

The reliability of scores for plaque, bleeding, suppuration, and probing pocket depth in identifying sites with probing attachment loss was evaluated in all the subjects from *Papers I, II and III* using sites with an initial probing pocket depth ≥ 4.0 mm. 2 groups of sites with probing attachment loss were identified with linear regression analysis as described above and used for determination of diagnostic sensitivity and predictability ratios in per-cent as follows:

Score	Probing attachment loss	
	Presence	Absence
Positive	a	b
Negative	c	d

Sensitivity $= \frac{a}{a+c}$

Predictability $= \frac{a}{a+b}$

Diagnostic sensitivity expresses the proportion of sites with attachment loss that shows a positive score (true positive ratio). Diagnostic predictability gives the proportion of sites with positive score that shows loss of probing attachment. Both sensitivity and predictability should approach 100% for reliable tests (*Paper VI*).

Results

DISTRIBUTION OF MATERIAL

All patients received a combined therapy of oral hygiene instruction and supra- and subgingival debridement. Because of variations in design of the original 3 studies (*Papers I, II and III*), some differences in therapy existed:

- 1) start of instrumentation (at baseline or at 3 months);
- 2) number of instrumentations (1 or 3);
- 3) use of instruments (hand or ultrasonics);
- 4) operator for instrumentation (7 different operators).

A total of 49 subjects and 2532 surfaces were treated. The distribution of subjects and surfaces of the different investigations (*Papers I, II and III*), with respect to operator for instrumentation, use of hand and/or ultrasonic instruments and frequency of instrumentation is presented in Tables 1 and 2. In all, 572 sites with an initial probing pocket depth ≤ 3.5 mm, 1168 surfaces initially 4.0 - 6.5 mm and 792 sites with an initial probing pocket depth ≥ 7.0 mm were treated.

For the purpose of presentation in this thesis, the materials from the 3 separate studies (*Papers I, II and III*) were pooled. Analyses of subgroups were performed in different ways for the various analytical purposes. The source and distribution of material analysed for different purposes is described in connection with the presentation of the results.

HEALING RESPONSE TO NONSURGICAL PERIODONTAL THERAPY

For the purpose of evaluation of the longitudinal healing response, 33 subjects and a total of 1368 surfaces from *Papers II and III*, treated by a single episode of instrumentation at baseline, were analysed (Figs. 1-6). For analysis of changes at 24 months related to mm-increments of initial and residual probing pocket depth, all the 49 subjects and a total of 2532 surfaces of *Papers I, II and III* were pooled (Figs. 7-10).

Table 1. Distribution of subjects by study, operator, hand and/or ultrasonic instrumentation and frequency of instrumentation

Paper no.	No. of subjects							
	Opera- tor 1	Opera- tor 2	Opera- tors 3 through 7	Hand instru- ments	Ultra- sonics	Hand and/or ultra- sonics	1 instru- menta- tion	3 instru- menta- tions
I	8	8		16	16			16
II	13				13		13	13
III		20	20			20	20	
Total	21	28	20	16	29	20	33	29

Table 2. Distribution of surfaces by study, operator, hand and/or ultrasonic instrumentation and frequency of instrumentation

Paper no.	No. of surfaces							
	Opera- tor 1	Opera- tor 2	Opera- tors 3 through 7	Hand instru- ments	Ultra- sonics	Hand and/or ultra- sonics	1 instru- menta- tion	3 instru- menta- tions
I	432	420		426	426			852
II	624				624		312	312
III		528	528			1056	1056	
Total	1056	948	528	426	1050	1056	1368	1164

Dental plaque

Initially, 39% of the shallow sites (≤ 3.5 mm) and 78-82% of the deeper sites showed presence of plaque. After 3 months the plaque scores were markedly reduced ($< 20\%$) and remained low throughout the study. The scores for the deeper surfaces remained somewhat higher than the scores for the shallow sites (Fig. 1).

Bleeding on probing

At the initial examination, 47% of the shallow sites (≤ 3.5 mm) and 81-90% of the deeper surfaces demonstrated bleeding on probing. 3 months after start of oral hygiene instruction and instrumentation, the bleeding scores were reduced to approximately 10% and 25% , respectively. A slight further reduction took place during the subsequent months until average levels of 5% and 15% were reached, which were maintained during the entire observation period (Fig. 2).

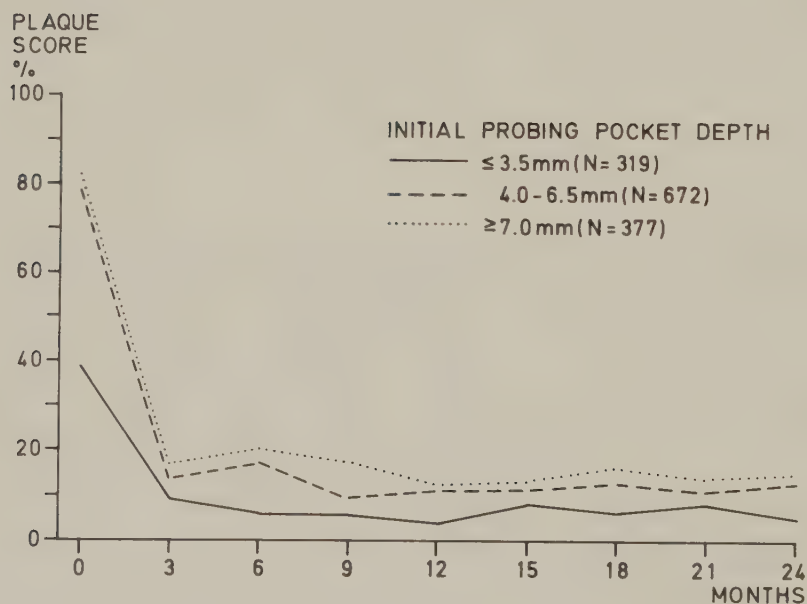


Fig. 1. Plaque scores for surfaces with initial probing pocket depth ≤ 3.5 mm, 4.0 - 6.5 mm and ≥ 7.0 mm at the 3-month recording intervals throughout the 24 months of study. N = number of available surfaces.

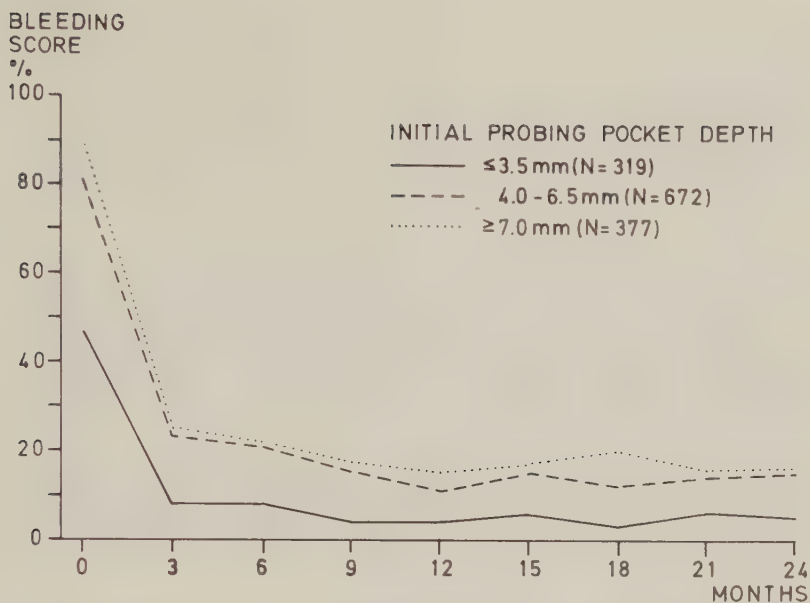


Fig. 2. Bleeding scores for surfaces with initial probing pocket depth ≤ 3.5 mm, 4.0 - 6.5 mm and ≥ 7.0 mm at the 3-month recording intervals throughout the 24 months of study.

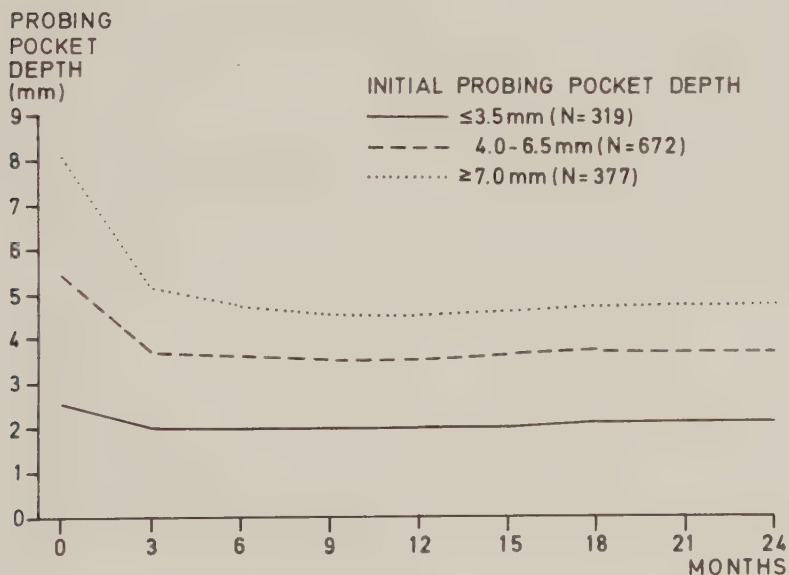


Fig. 3. Probing pocket depths for surfaces with initial probing pocket depth ≤ 3.5 mm, 4.0 - 6.5 mm and ≥ 7.0 mm at the 3-month recording intervals throughout the 24 months of study.

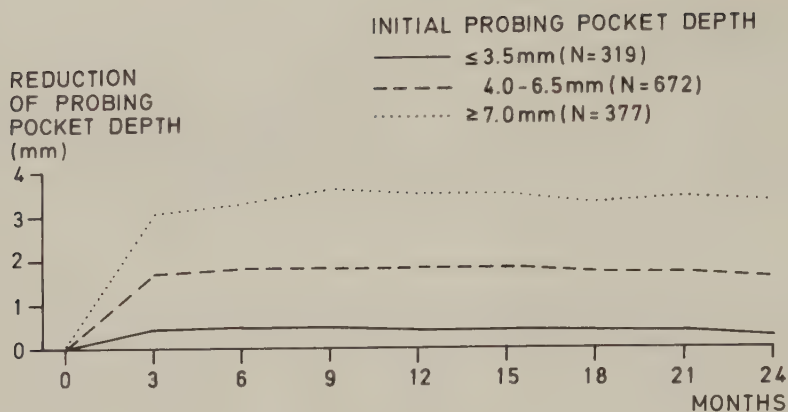


Fig. 4. Reductions of probing pocket depth for surfaces with initial probing pocket depth ≤ 3.5 mm, 4.0 - 6.5 mm and ≥ 7.0 mm at the 3-month recording intervals throughout the 24 months of study.

Probing pocket depth

The mean changes of probing pocket depths are presented in Figs. 3 and 4. The amount of pocket reduction was most notable for surfaces showing the greatest initial pocket depth. The mean depth of sites initially ≤ 3.5 mm were reduced by around 0.5 mm 3 months after start of oral hygiene instruction and instrumentation. Surfaces with an initial probing pocket depth of 4.0 - 6.5 mm were reduced by approximately 1.7 mm at 3 months. No further reduction took place for these shallow and moderately deep sites during the rest of the observation period. Sites initially ≥ 7.0 mm demonstrated an average pocket reduction of 3.0 mm after 3 months. A slight further reduction took place during the subsequent months until the 9-month examination, when the pocket depths were stabilized with a total reduction of around 3.5 mm.

Gingival recession

Most of the gingival recession occurred during the first 3 months. Sites with deeper initial probing pocket depth showed more recession than shallower areas (Fig. 5).

Probing attachment level

A slight gradual mean loss of attachment throughout the experimental period was observed for surfaces with initial probing pocket depth ≤ 3.5 mm. This loss of attachment amounted to approximately 0.8 mm after 24 months. Gain of

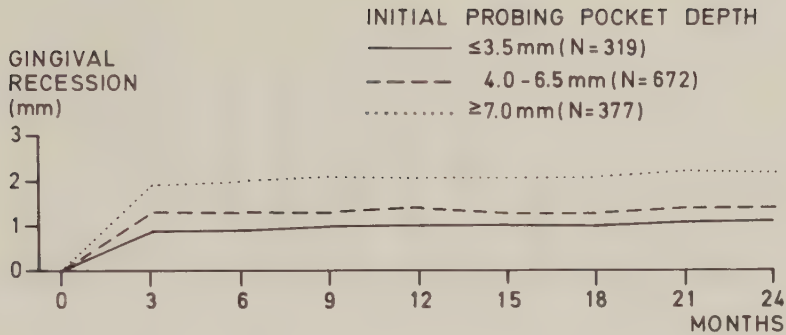


Fig. 5. Gingival recession for surfaces with initial probing pocket depth ≤ 3.5 mm, 4.0 - 6.5 mm and ≥ 7.0 mm at the 3-month recording intervals throughout the 24 months of study

attachment was found for sites with initially deeper probing pocket depth. Surfaces, initially ≥ 7.0 mm deep, showed 1.1 mm average gain of attachment at the 24 month examination (Fig. 6).

Changes related to initial probing pocket depth

The data from all surfaces of all patients have been pooled and grouped according to initial probing pocket depth of the individual surfaces in Fig. 7. Sites with initially deeper probing pocket depth showed more gingival recession, more gain of probing attachment and deeper residual probing depth at 24

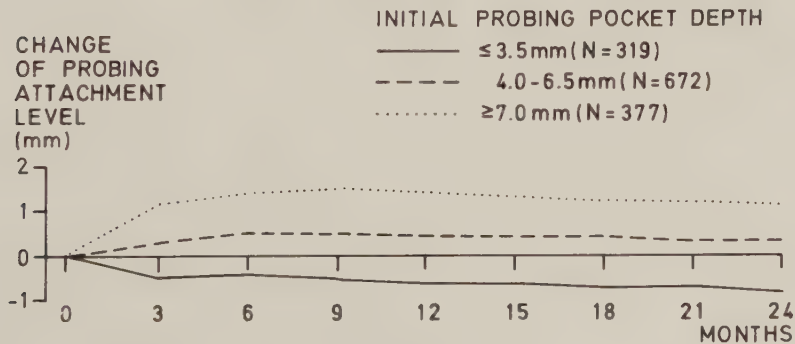


Fig. 6. Changes of probing attachment level for surfaces with initial probing pocket depth ≤ 3.5 mm, 4.0 - 6.5 mm and ≥ 7.0 mm at the 3-month recording intervals throughout the 24 months of study.

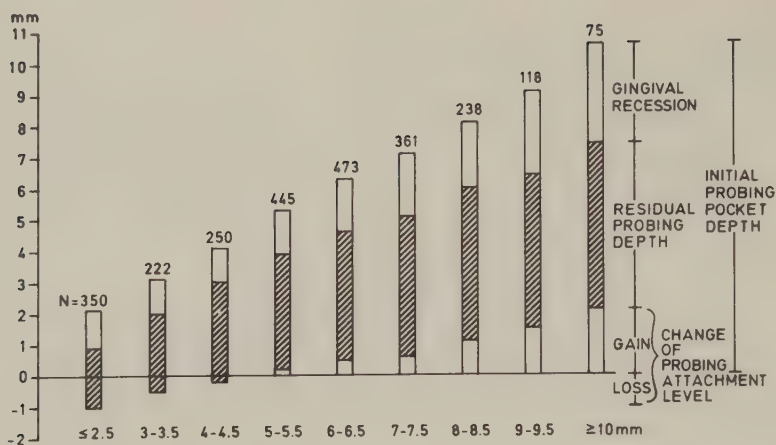


Fig. 7. Mean amounts of gingival recession, residual probing depth and gain/loss of probing attachment level at 24 months related to initial probing pocket depth. Pooled surfaces from 49 subjects.

months than sites with initial shallow pocket depth. Surfaces with initial probing pocket depth ≤ 4.5 mm demonstrated 0.2 - 1.0 mm average loss of probing attachment, whilst sites initially ≥ 8.0 mm deep showed 1.1 - 2.1 mm average gain of probing attachment.

Attachment changes related to residual probing depth

The mean changes in probing attachment level for pooled surfaces of different residual probing depth at 24 months are presented in Fig. 8. Surfaces with residual probing depth ≤ 2.5 mm and ≥ 6.0 mm seemed to have lost some probing attachment, whilst surfaces with a residual pocket depth of 3.0 - 5.5 mm seemed to have undergone a minor gain of attachment.

Relationship of bleeding on probing and probing pocket depth

The proportion of bleeding surfaces at the initial examination was 87% or more for surfaces with initial probing pocket depth ≥ 5.0 mm (Fig. 9). At the 24-month examination the bleeding frequencies were markedly reduced not only for shallow pockets, but also for pockets of deep initial probing depth.

The bleeding frequencies at the 24-month examination related to residual probing depth are shown in Fig. 10. Bleeding upon probing was encountered more often in pockets with deeper residual probing depth than in shallow sites.

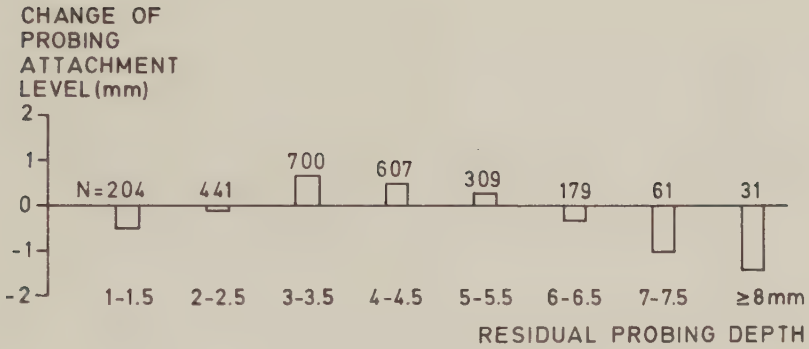


Fig. 8. Mean change of probing attachment level for surfaces with different residual probing depths at 24 months. Pooled surfaces from 49 subjects.

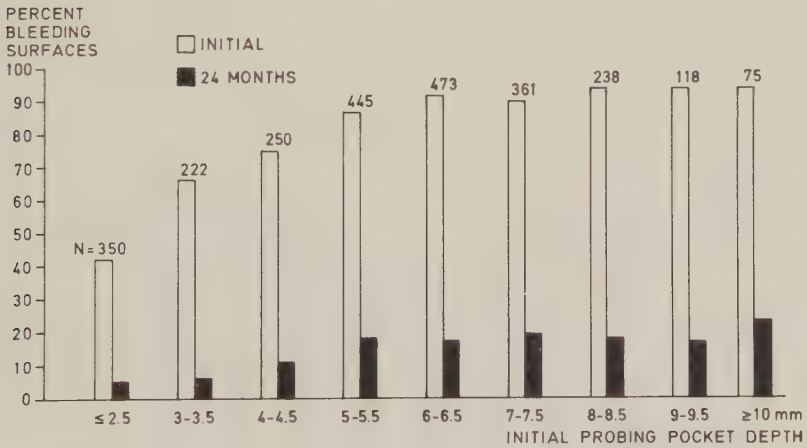


Fig. 9. Proportions (%) of surfaces showing bleeding upon probing at initial examination and at 24 months grouped by initial probing pocket depth. Pooled data from 49 subjects.

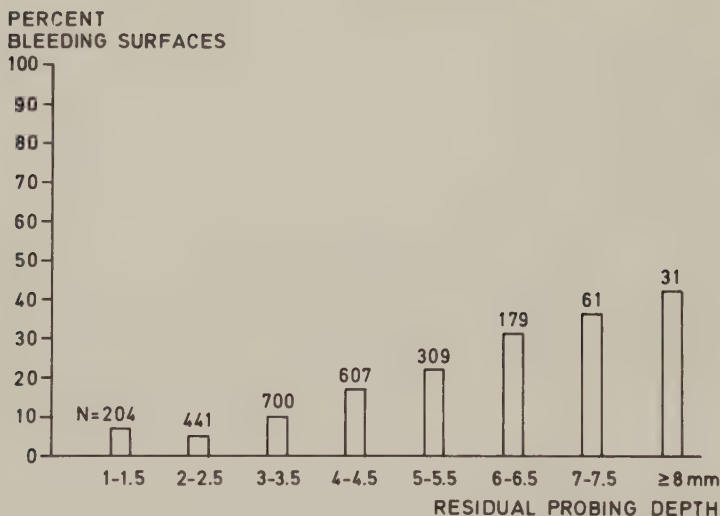


Fig. 10. Proportions (%) of surfaces showing bleeding upon probing at the 24-month examination grouped by residual probing depth at 24 months. Pooled data from 49 subjects.

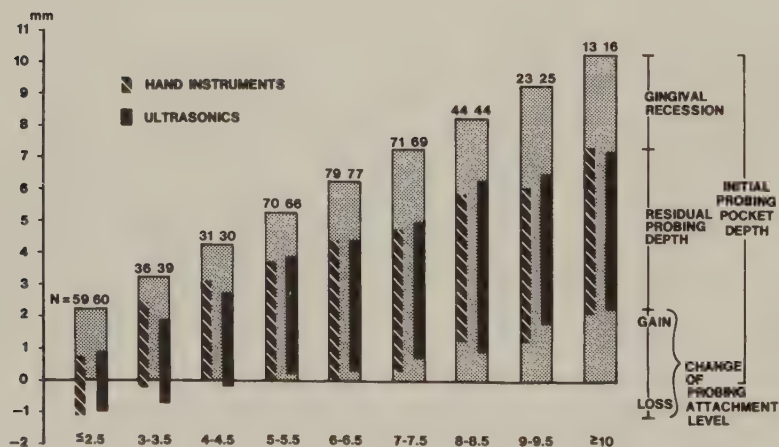


Fig. 11. Mean amounts of gingival recession, residual probing depth and gain/loss of probing attachment level at 24 months related to initial probing pocket depth. Pooled surfaces for hand and ultrasonic instruments from 16 subjects.

METHOD OF INSTRUMENTATION

For the purpose of comparison of the results obtained by hand and ultrasonic instruments, 16 subjects and a total of 852 surfaces from *Paper I* were analysed (Fig. 11). The data from all surfaces of the 16 subjects have been pooled and grouped according to initial probing pocket depth and method of instrumentation. Similar healing events could be observed comparing the results of hand and ultrasonic instrumentation.

FREQUENCY OF INSTRUMENTATION

For the purpose of comparison of the results obtained by single and repeated instrumentation, 13 subjects and a total of 624 surfaces from *Paper II* were analysed (Fig. 12). The data from all surfaces of the 13 subjects have been pooled and grouped according to initial probing pocket depth and frequency of instrumentation. No differences in result could be observed between the effect of a single instrumentation and 3 instrumentations.

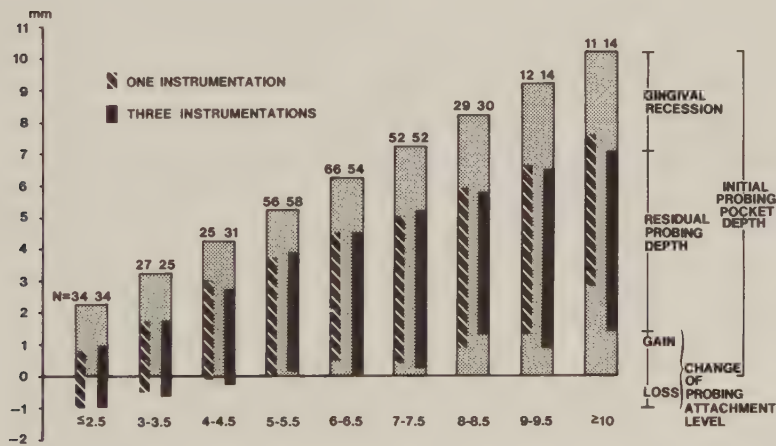


Fig. 12. Mean amounts of gingival recession, residual probing depth and gain/loss of probing attachment level at 24 months related to initial probing pocket depth. Pooled surfaces for 1 and 3 instrumentations from 13 subjects.

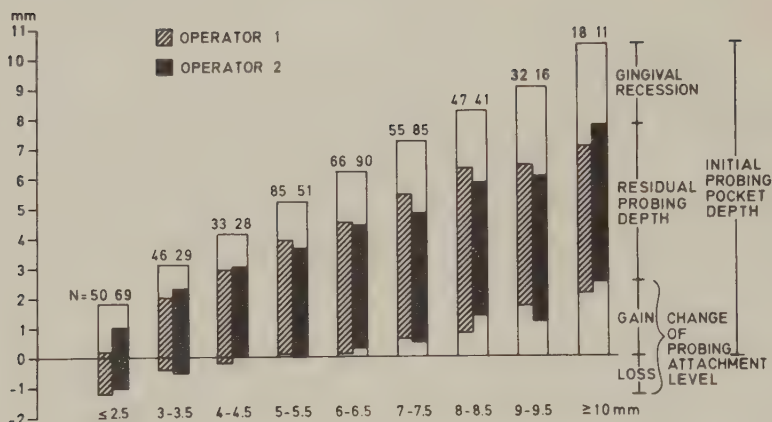


Fig. 13. Mean amounts of gingival recession, residual probing depth and gain/loss of probing attachment level at 24 months related to initial probing pocket depth. Pooled surfaces for operators 1 and 2 from 16 subjects.

OPERATOR VARIABILITY

For the purpose of evaluation of the effect of operator variability, the materials of *Paper I* (16 subjects, 852 surfaces) and *Paper III* (20 subjects, 1056 surfaces) were used (Figs. 13-14). The data from all surfaces of the 36 subjects have been pooled and grouped according to initial probing pocket depth and operator for instrumentation. In Fig. 13 operator 1 is compared to operator 2. Similar healing events could be observed comparing the results of these 2 operators. In Fig. 14, operator 2 is compared to the collective values for operators 3 through 7. Sites treated by operator 2 showed slightly less recession and slightly more gain in probing attachment than sites treated by operators 3 through 7.

PATTERN OF PROBING ATTACHMENT LOSS IN NON-RESPONDING SITES

For the purpose of analysis of patterns of probing attachment loss following therapy in non-responding sites, 33 subjects and a total of 1368 sites from *Papers II and III*, treated by a single episode of instrumentation at baseline, were analysed (Fig. 15).

From the total of 1368 sites, 280 "non-responding" sites were selected. The study of scatter diagrams of the sequence of 9 probing attachment recordings

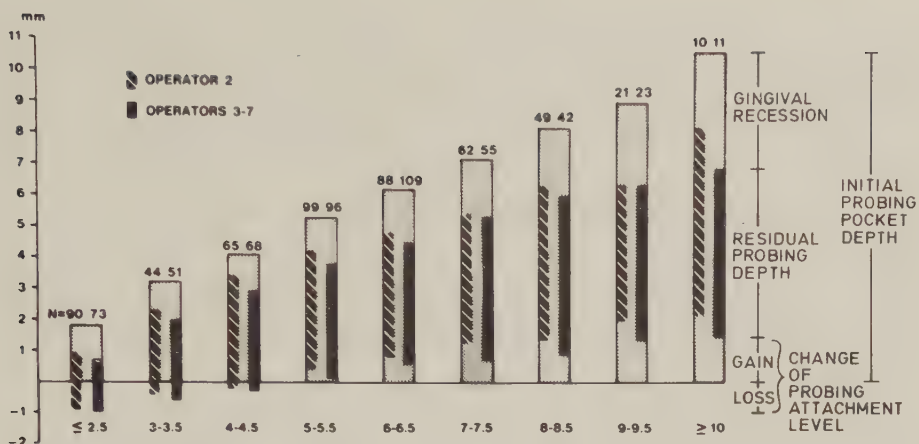


Fig. 14. Mean amounts of gingival recession, residual probing depth and gain/loss of probing attachment level at 24 months related to initial probing pocket depth. Pooled surfaces for operator 2 and operators 3 through 7 from 20 subjects.

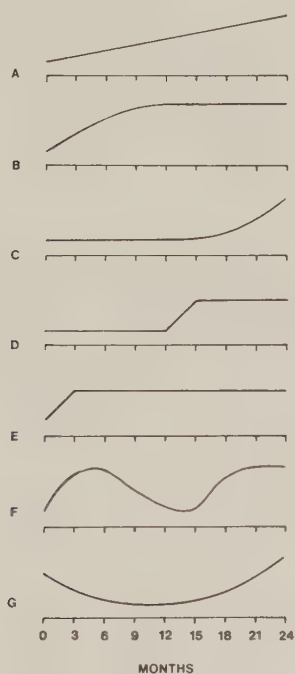


Fig. 15. Patterns of probing attachment level change recognized amongst 280 "non-responding" sites.

obtained during the 24 months for each of these sites resulted in identification of 7 different patterns of probing attachment change over time (Fig. 15). A linear pattern of gradual loss of probing attachment throughout the 24-month observation period was found for 73% of the non-responding sites (Pattern A). A loss of probing attachment between the 0- and 3-month recordings followed by stable measurements throughout the remaining observation period (Pattern E) was observed for 12% of the sites. A gradual loss of probing attachment during an early portion of the observation period followed by a stabilized probing attachment level (Pattern B) was found for 5% of the sites. Other patterns were less frequent (Table 3).

IDENTIFICATION AND LOCALIZATION OF SITES WITH PROBING ATTACHMENT LOSS

For the purpose of identification of sites with probing attachment loss following therapy and to study the localization of these sites, 49 subjects and a total of 2532 sites from *Papers I, II and III* were analysed (Tables 4-5).

The use of $\Delta y > 1.5$ mm and $p < 0.05$ for selection of sites with probing attachment loss (Group 1) yielded 120 sites (5%) out of the total of 2532 available sites (Table 4). Reducing the required projected loss of attachment to $\Delta y > 1.0$ mm and maintaining $p < 0.05$, generated another 145 sites, resulting in 265 sites (10%) in Group 2 (Table 5).

In both groups, attachment loss was more frequently noticed for sites with an

Table 3. Percentage of non-responding sites by pattern of probing attachment loss and initial probing pocket depth

Initial probing pocket depth (mm)	Pattern						
	A	B	C	D	E	F	G
≤ 3.5 (N=147)	72	8	1	1	16	1	0
4.0 - 6.5 (N=101)	81	1	2	4	9	1	2
≥ 7.0 (N=32)	53	3	13	9	3	9	9
Mean (N=280)	73	5	3	3	12	2	2

initial probing depth ≤ 3.5 mm than for sites initially 4.0 - 6.5 mm deep, which in turn showed higher frequency than sites initially ≥ 7.0 mm deep. Overall, buccal tooth surfaces showed a higher incidence of sites with probing attachment loss than proximal and lingual surfaces.

BLEEDING, SUPPURATION AND PROBING POCKET DEPTH IN SITES WITH PROBING ATTACHMENT LOSS

For the purpose of determination of diagnostic sensitivity and predictability for bleeding on probing, suppuration and probing pocket depth in sites with probing attachment loss, 49 subjects and 1960 sites with an initial probing pocket depth ≥ 4.0 mm from *Papers I, II and III*, were analysed (Table 6).

The use of $\Delta y > 1.5$ mm and $p < 0.05$ for selection of sites with probing attachment loss (Group 1) yielded 62 sites (3%) out of the total of 1960 available sites. Reducing the required projected loss of attachment to $\Delta y > 1.0$ mm, maintaining $p < 0.05$, generated another 71 sites, resulting in 133 sites (7%) in Group 2.

Table 4. Distribution of sites with probing attachment loss by initial probing pocket depth and by tooth surface. Group 1: $\Delta y > 1.5$ mm, $p < 0.05$

Tooth surface	Initial probing pocket depth (mm)								
	≤ 3.5			4.0 - 6.5			≥ 7.0		
	Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss	
		Num-ber	Per-cent		Num-ber	Per-cent		Num-ber	Per-cent
Buccal	352	39	11	55	4	7	15	1	7
Lingual	119	6	5	239	1	0	64	2	3
Proximal	101	13	13	874	40	5	713	14	2
Total	572	58	10	1168	45	4	792	17	2

Table 5. Distribution of sites with probing attachment loss by initial probing pocket depth and by tooth surface. Group 2: $\Delta y > 1.0$ mm, $p < 0.05$

Tooth surface	Initial probing pocket depth (mm)								
	≤ 3.5			4.0 - 6.5			≥ 7.0		
	Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss	
		Num-ber	Per-cent		Num-ber	Per-cent		Num-ber	Per-cent
Buccal	352	89	25	55	7	13	15	1	7
Lingual	119	20	17	239	7	3	64	5	8
Proximal	101	23	23	874	79	9	713	34	5
Total	572	132	23	1168	93	8	792	40	5

The sensitivity and predictability values for some clinical criteria are presented in Table 6. In the material there were 96 sites available that displayed bleeding at 7 examinations or more. The predictability and sensitivity values for that frequency of bleeding were around 25% in both groups of sites with attachment loss. Thus, only 25% of the sites with probing attachment loss showed bleeding this often and only 25% of the sites with this bleeding frequency showed probing attachment loss. Similarly, there were 90 sites available that showed a residual probing depth at 24 months of 7.0 mm or more. The sensitivity and predictability values ranged between 27-40%. At 18 or 24 months, 97 sites showed suppuration with sensitivity and predictability values ranging from 17% to 30%.

Around 40-50% of sites that showed an increase in probing depth of 0.5 mm or more at 24 months compared to baseline had lost probing attachment. Out of sites with probing attachment loss, 30-50% demonstrated 0.5 mm increase in probing depth. Approximately 70-90% of sites with attachment loss, established

Table 6. Sensitivity and predictability values in percent for bleeding frequency ≥ 7 , residual probing depth ≥ 7.0 mm at 24 months, suppuration at 18 or 24 months, increase in probing pocket depth ≥ 0.5 mm between 0-24 months, and loss of probing attachment ≥ 1.5 mm between 0-24 months

Criteria	Group 1 (N=62)		Group 2 (N=133)	
	Sensi- tivity	Predict- ability	Sensi- tivity	Predict- ability
Bleeding frequency ≥ 7 (N=96)	29	23	20	28
Residual probing depth ≥ 7.0 mm at 24 months (N=90)	39	27	27	40
Suppuration at 18 or 24 months (N=97)	26	17	22	30
Increase in prob- ing pocket depth ≥ 0.5 mm 0-24 months (N=77)	48	39	30	52
Loss of probing attachment ≥ 1.5 mm 0-24 months (N=126)	89	44	68	71

by regression analysis, demonstrated a loss of probing attachment of 1.5 mm or more at 24 months compared to baseline. The predictability values of probing attachment loss ≥ 1.5 mm at 24 months were around 45-70%.

Discussion

HEALING RESPONSE TO THERAPY

The present studies investigated the effects of oral hygiene instruction and supra- and subgingival debridement on severely advanced periodontitis and extended the observations made in a previous investigation performed on moderately advanced periodontitis (Badersten et al. 1981). The result demonstrated that nonsurgical therapy resulted in marked improvement of gingival conditions not only in periodontal pockets of moderate depth but also in pockets up to 12 mm deep.

Healing following nonsurgical periodontal therapy is a gradual process over several months involving gingival recession and improved adaptation of the gingival tissues. More advanced disease with deeper pockets continued to improve during a longer period than less advanced lesions. In the shallower sites, the improvements of bleeding score, pocket depth and attachment level levelled off after 3-6 months, which is in agreement with the results from a previous study (Badersten et al. 1981). In deeper sites the periodontal conditions continued to improve during 6-9 months following start of therapy. This gradual improvement in deeper sites was also observed by Lindhe et al. (1982b). In root planed sites, which were >6 mm at the 6-month reexamination, they observed an additional gain of 1.2 mm in probing attachment from the 6th to the 12th month of the study. These results indicate that the decision to institute supplementary surgical therapy following the initial nonsurgical phase should not be made until 9-12 months after start of therapy if it is intended to evaluate the full effect of the initial therapy.

The probing pocket depth of sites initially ≥ 5.0 mm deep were markedly reduced following the conservative therapeutic approach. The probing attachment levels were also improved. The deeper the initial probing pocket depth, the more gingival recession, pocket reduction and gain of attachment was obtained. The limited proportion of sites with continued probing attachment loss in pockets initially 7.0 mm or deeper, identified by linear regression analysis,

indicated that progression of disease can be prevented by nonsurgical therapy in the vast majority of deep sites.

Some mean loss of probing attachment was observed for sites with initially shallow probing pocket depth. Also, linear regression analysis disclosed a comparatively high proportion of shallow sites with probing attachment loss. Attachment loss for shallow sites following nonsurgical therapy has previously been reported by Badersten et al. (1981), Hill et al. (1981), Isidor (1981), Lindhe et al. (1982a, b), Cercek et al. (1983) and Pihlstrom et al. (1983).

Attachment loss in shallow sites may be caused by trauma from instrumentation during the initial phase of therapy as the study of scatter diagrams of probing attachment changes in several of these sites disclosed an initial loss of probing attachment followed by a stabilization of the probing levels during the remaining observation period (Patterns B and E). Scatter diagrams from other shallow sites with probing attachment loss, however, indicated a slight but gradual loss of attachment throughout the entire 24-month period that probably could not be accounted for by instrumentation injury. Interestingly, Cercek et al. (1983) also found some loss of probing attachment in sites with shallow probing depth following oral hygiene procedures alone without any concomitant instrumentation of the teeth. Vigorous tooth cleaning procedures may possibly explain this attachment loss. Data from the present studies may also indicate loss of attachment due to tooth cleaning. Sites instrumented once, at baseline only, continued to show some gradual attachment loss during the 24 months of observation (Fig. 6).

Similar magnitudes of mean changes in probing pocket depth and probing attachment level following nonsurgical therapy as observed in the present studies have been reported by Hill et al. (1981), Isidor (1981), Lindhe et al. (1982a, b) and Pihlstrom et al. (1983). The fact that deep pockets showed more gain of probing attachment than moderately deep pockets, combined with the fact that they demonstrated similar reduction of bleeding upon probing, indicate that there is no certain magnitude of initial probing pocket depth where nonsurgical periodontal therapy is no longer effective. The findings by Hill et al. (1981), Isidor (1981), Lindhe et al. (1982a, b) and Pihlstrom et al. (1983) indicated that scaling and root planing was equally effective in establishing periodontal health and in preventing further loss of attachment as scaling and root planing combined with a flap procedure. However, the probing pocket depth reduction during the first year of observation was more pronounced in sites subjected to surgery than in sites exposed to scaling and root planing alone. This difference between procedures was not consistently found following longer observation periods (Hill et al. 1981,

Lindhe et al. 1982a, b, Pihlstrom et al. 1983).

Goodson et al. (1982) studied changes in probing attachment levels over periods of up to 23 months in patients with untreated periodontitis and observed sites that became progressively deeper during the monitoring period together with sites that showed a pattern of early probing attachment loss and subsequent probing attachment gain. Also, sites that were initially stable but showed probing attachment loss at the end of the monitoring period were observed. In the present study of patients monitored following initial periodontal therapy, patterns of probing attachment change similar to those described by Goodson et al. (1982) were observed. 73% of the non-responding sites showed a gradual, linear deterioration of the probing attachment levels (Pattern A). Another 11% of the sites showed attachment level changes approximating a linear pattern (Patterns B, C and D). Compared to these linear changes of probing attachment, all other patterns of probing attachment change were relatively infrequent. This finding corresponds to previous observations that periodontal disease, on the average, progresses gradually over time (Löe et al. 1978, Axelsson & Lindhe 1981a, b).

The limitation of the present studies to non-molar teeth should be carefully considered. Results of therapy may be more limited in molars, especially in furcation areas of these teeth. The studies by Hill et al. (1981), Lindhe et al. (1982a, b) and Pihlstrom et al. (1983) included molars but utilized primarily flat surface measurements in the molars. Lindhe et al. (1982a) compared the healing of non-molar and molar teeth and found slightly more improvements of mean probing pocket depth and mean probing attachment level following nonsurgical therapy in the non-molar teeth. The differences, however, were reported to be statistically in-significant.

METHOD OF TREATMENT

The similarity of results following hand and ultrasonic instrumentation is in agreement with the findings by Torfason et al. (1979) and Badersten et al. (1981). Adequate debridement of the contaminated root surfaces in deep pockets can apparently be accomplished by ultrasonics as well as by hand instruments. It appears that the reported limitations of ultrasonic instruments to remove cementum and to smooth the root surfaces have little clinical significance.

A similar healing response was accomplished by a single, initial instrumentation as by 3 instrumentations, each separated by 3 months. This indicates that an adequate debridement during the initial instrumentation was accom-

lished and - if a number of surfaces was not adequately instrumented initially - repeated instrumentation of these sites seemed to be of limited value.

Slots et al. (1979) and Mousquès et al. (1980) have demonstrated that subgingival recolonization may occur within a few months following instrumentation. Magnusson et al. (1984) observed that presence of dental plaque along the gingival margin facilitates spirochete repopulation subgingivally. As healing following nonsurgical periodontal therapy is a gradual process over several months, it is conceivable that subgingival recolonization by microorganisms may easily occur during this phase before sufficient gingival healing and adaptation has taken place. Repeated instrumentation during this period would facilitate continuous improvement and prevent recurrence of disease. However, the lack of differences in results between a single instrumentation and repeated instrumentations seems to suggest that recolonization during the healing phase is not a major problem. It should be emphasized that this finding may be valid for the investigated conditions only: non-molar teeth in patients with good plaque control.

The study of scatter diagrams of probing attachment changes in non-responding sites disclosed a few individual sites with a stable probing attachment level during the first months of observation followed by probing attachment loss at the end of the monitored period (Patterns C and D). These patterns were most frequent in sites with an initial probing pocket depth of 7.0 mm or more and may indicate occasional localized recurrence of disease caused by microbial repopulation subgingivally.

A previous study in moderately advanced disease did not demonstrate any differences in result of therapy following repeated instrumentation by 2 participating operators (operators 1 and 2, Badersten et al. 1981). Both of these therapists were experienced periodontists. In the present investigations in severely advanced periodontitis, the results obtained by these same operators were again similar; following repeated as well as a single episode of instrumentation. The present findings also demonstrated successful results and similar healing response following a single episode of instrumentation by 5 dental hygienists (operators 3 through 7). Further evidence of successful nonsurgical periodontal therapy is found in the studies by Hill et al. (1981), Isidor (1981), Lindhe et al. (1982a,b) and Pihlstrom et al. (1983). In spite of the fact that the treatment employed in these investigations has been performed in different clinics and by different operators, the results are comparable. Therefore, it seems that in the circumstances appertaining to a clinical research environment, the effect of operator variability on the results of nonsurgical periodontal therapy is minimal.

Most of the examined surfaces showed bleeding on probing at the initial examination. The therapy resulted in substantial reduction of the bleeding frequencies, including sites with deep initial probing pocket depths. Some surfaces, however, still showed bleeding after treatment. The proportion of surfaces, where bleeding could be provoked after therapy, was somewhat higher for surfaces with deeper residual probing depth than for surfaces with shallow residual depth. At 24 months, 31-42% of the surfaces with ≥ 6.0 mm residual probing depth bled upon probing. Also, these surfaces demonstrated some average loss of attachment. These circumstances seem to indicate that bleeding on probing is a useful clinical parameter to disclose continued disease. On the other hand, 10-22% of surfaces with 3.0 - 5.5 mm residual probing depth also showed bleeding on probing at 24 months. These surfaces had undergone a small average improvement of probing attachment level.

Analyses of individual sites with probing attachment loss showed that loss of attachment was somewhat more frequent for surfaces showing bleeding upon probing at several examinations than for other sites. However, the diagnostic sensitivity and predictability values of bleeding scores were low. For bleeding frequency of 7 or more times of 9 examinations, these diagnostic values were around 25%. A diagnostic sensitivity of 25% means that only 1 of 4 deteriorating sites showed this bleeding frequency. A diagnostic predictability of 25% means that only 1 of 4 sites with this bleeding frequency was deteriorating. These results confirm the observations of Haffajee et al. (1983a). They found that the sensitivity of bleeding on probing was 32% and concluded that this clinical sign is not useful in predicting disease activity at individual sites.

The results showed that the predictability values for suppuration and for deep residual probing depth did not exceed 30-40%. An increase in probing depth of 0.5 mm or more at 24 months compared to baseline yielded predictability values around 40-50%. Thus, the probability of identifying a deteriorating site using any of the above recordings is, at best, 1 out of 2. Analyses were performed combining signs of bleeding, suppuration and probing depth for individual sites. However, these combinations did not improve the diagnostic reliability.

As expected, attachment loss calculated from recordings at 24 months minus baseline recordings showed favorable diagnostic sensitivity and predictability for attachment loss calculated by regression analysis. A loss of attach-

ment of ≥ 1.5 mm at 24 months compared to baseline demonstrated both sensitivity and predictability values of around 70% for group 2 sites ($\Delta y > 1.0$ mm, $p < 0.05$). This means that a recorded loss of probing attachment of 1.5 mm or more following therapy reflects attachment loss established by linear regression and may be used as a cut-off point for clinical purposes to identify deteriorating sites.

The results of the present studies confirmed the findings by Haffajee et al. (1983a) that clinical evaluations of bleeding on probing, suppuration, or probing pocket depth can not be used to determine deterioration of periodontal probing attachment levels. Persistent bleeding, suppuration and deep probing depth following initial, nonsurgical periodontal therapy would seem to indicate that the therapy was ineffective in eradicating inflammation of the tissue. However, the persistence of these clinical signs of inflammation seem to have limited bearing on attachment loss within a time frame of 24 months. These findings should not be used to justify neglect of continuous bleeding, suppuration or deep residual probing depth following therapy. Given longer observation intervals persistence of these criteria may be indicative of probing attachment loss. Nevertheless, the findings of this study justify a cautious interpretation of clinical findings at reevaluation following initial therapy. Also, a therapist who elects to institute supplementary surgical therapy following reevaluation based upon clinical signs of bleeding, suppuration and deep residual probing depth should be aware that he may be treating residual symptoms of the disease rather than the disease itself. Finally, the findings of the present studies demonstrate that records of bleeding, suppuration and probing depth can not substitute for probing attachment level measurements.

Conclusions

From the present series of investigations the following conclusions can be made:

Substantial improvement of periodontal conditions can be accomplished following nonsurgical periodontal therapy in severely advanced periodontitis of non-molar teeth.

Healing following nonsurgical therapy is a gradual process over several months. More advanced disease with deeper pockets continue to improve during a longer period than less advanced lesions.

Similar healing events seem to occur following hand and ultrasonic instrumentation.

A single episode of instrumentation can be equally effective as repeated instrumentations.

The effect of operator variability on the results of therapy seems to be minimal.

A linear pattern of gradual loss of probing attachment occurs in the majority of non-responding sites.

The majority of sites with probing attachment loss is found amongst initially shallow or moderately deep lesions.

Diagnostic sensitivity and predictability ratios of bleeding scores, suppuration, and probing pocket depth demonstrate that these recordings can not substitute for probing attachment level measurements in evaluating the effect of therapy.

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Paper I

Effect of nonsurgical periodontal therapy

II. Severely advanced periodontitis

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Abstract. Healing events following nonsurgical periodontal therapy in patients with periodontal pockets up to 12 mm deep were investigated. Incisors, cuspids and premolars in 16 patients were treated by plaque control and supra- and subgingival debridement using hand or ultrasonic instruments in a split mouth approach. The results were evaluated by recording of plaque scores, bleeding on probing, probing pocket depths and probing attachment levels. Minimal change in gingival conditions occurred during the initial 3 months of experimentation, which were utilized for plaque control measures alone. Subsequent to instrumentation and during the following 9-month period, a gradual and marked improvement of periodontal conditions took place. During the remaining 12 months of the 24-month experimental period no further changes of the recorded parameters were noted. No differences in results could be observed when comparing hand versus ultrasonic instrumentation, or when comparing the results of 2 different operators. Initially, a total of 305 sites demonstrated probing pocket depths ≥ 7 mm. At the 24-month examination 43 such sites remained. The results indicate that there is no certain magnitude of initial probing pocket depth where nonsurgical periodontal therapy is no longer effective.

In a previous study the effect of nonsurgical periodontal therapy was investigated in patients with periodontal pockets 4–7 mm deep (Badersten et al. 1981). The study was performed to accumulate information on healing events following oral hygiene instruction, supra- and subgingival debridement with hand and ultrasonic instruments. Marked improvement of the periodontal conditions was obtained, including sites with pockets initially 6–7 mm deep. The apparently successful results of conservative treatment of these patients raised the question to what extent nonsurgical therapy is feasible also in patients with severely advanced lesions. The present study was carried out to study healing events in patients with pockets up to 12 mm deep, and to compare effects of hand and ultrasonic instrumentation.

Material and Methods

16 patients, 38–58 years of age, 11 males and 5 females with severely advanced periodontal disease, were selected for the study. Incisors, cuspids and premolars in either the maxilla or the mandible were studied. A minimum of 4 and a maximum of 10 teeth were used in each patient. The areas of the dentition under study had generalized periodontal destruction involving both sides of the jaw to a similar extent. Clinical signs of gingival inflammation and periodontal pockets ≥ 5 mm deep with calculus and bleeding upon probing were present on 2 or more aspects of each tooth.

The therapy and methods of the present investigation were similar to those in our previous study (Badersten et al. 1981). In the

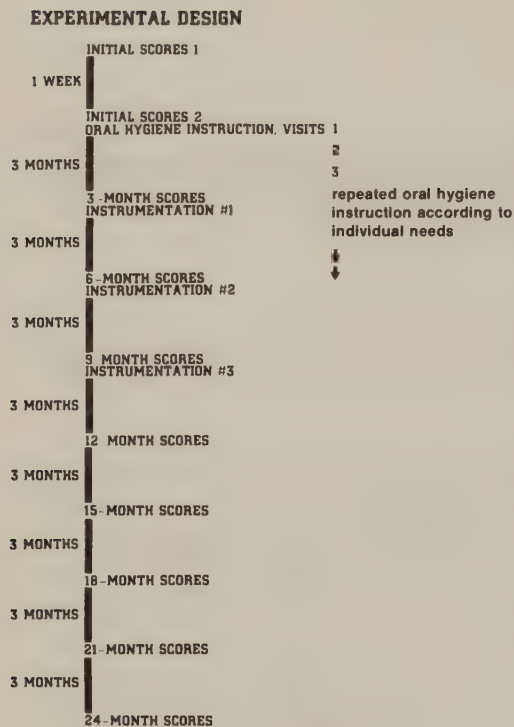


Fig. 1. Flow chart of the experimental design.

Versuchsablauf - Zeitfolge.

Organigramme du plan de l'expérience.

following only details which differed from the earlier investigation will be described.

The experimental design is shown in Fig. 1.

Oral hygiene instruction

Initial oral hygiene instruction was given in 2-3 visits during the first month of experimentation. Additional instruction and reinforcement as well as polishing of the teeth was provided according to individual needs for the entire duration of the study.

Debridement of periodontal pockets

Instrumentation (by means of hand instruments or ultrasonic instruments) was performed by 2 operators (authors J. E. and R. N.) treating 8 patients each. The first debridement was performed 3 months after start of experimenta-

tion. Repeated instrumentation was carried out at 6 and 9 months.

Methods of measurement

Measurements of dental plaque, bleeding on probing, probing pocket depth, probing attachment level and gingival recession were made every third month by one of the authors (A.B.) who was unaware of which instrumentation had been used for the different teeth. Recordings were made at 6 aspects of each tooth: mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual. 2 initial measurements of pocket depth and attachment level were taken 1 week apart to evaluate the intraexaminer reproducibility of the recordings.

At the initial recordings and at 18 and 24 months, a second examiner (author R.N.) also measured probing pocket depth and probing attachment level for the purpose of studying interexaminer reproducibility.

The probing measurements were taken after the recording of plaque and bleeding scores.

Table 1. Distribution of surfaces by initial probing pocket depth (in mm) and method of instrumentation
Verteilung der Oberflächen auf die initiale Sondierungstiefe (in mm) und auf die instrumentale Behandlungsmethode

Répartition des surfaces suivant la profondeur initiale de poche et la méthode d'instrumentation

Initial probing pocket depth (mm)	No. of surfaces	
	Hand instruments	Ultra- sonics
1.0- 1.5	10	12
2.0- 2.5	49	48
3.0- 3.5	36	39
4.0- 4.5	31	30
5.0- 5.5	70	66
6.0- 6.5	79	77
7.0- 7.5	71	69
8.0- 8.5	44	44
9.0- 9.5	23	25
10.0-10.5	9	11
11.0-11.5	4	3
12.0-12.5	—	2
Total	426	426

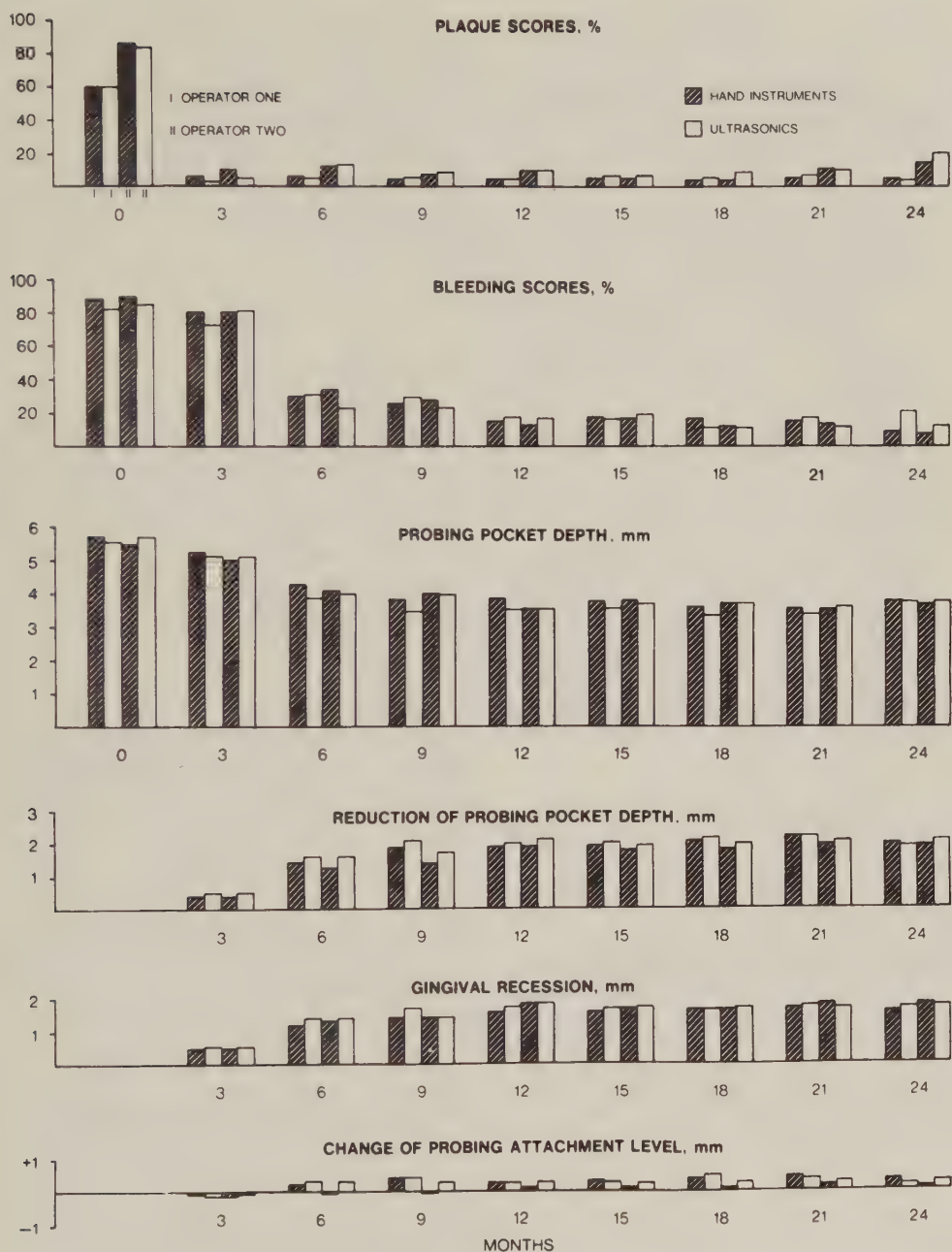


Fig. 2. Means of the recorded parameters by operator and method of instrumentation at the 3-month recording intervals throughout the 24 months of study.

Mittelwerte der vom Behandler registrierten Parameter und die instrumentale Behandlungsmethode, bei der in 3-monatlichen Anständen erfolgten Registrierungen der 24 Monate andauernden Studie.

Moyennes des paramètres enregistrés par opérateur et par méthode d'instrumentation lors des visites trimestrielles pendant les 2 années.

Probing pocket depth and probing attachment level

Probing pocket depths and probing attachment levels were measured to the nearest of half a mm with a specially machined and calibrated probe (0.5 mm in diameter, 1 mm increments). The probing force was not standardized. However, at the end of the study an electronic pressure sensitive probe was used to evaluate the probing force of the examiners (Electronic Periodontal Probe, model 200, Vine Valley Research, Middlesex, NY, U.S.A.). The force was found to be around 0.50–0.75 N.

The margins of soft acrylic onlays were used to provide reference points for the attachment level measurements (Drufosoft, Dreve, Unna, West Germany). Steering grooves were not made in the onlays. The proximal placement of the probe was guided by the interdental indentations on the thin onlay and the probe was directed apically at a slight angle to the long axis of the tooth. The buccal and lingual measurements were made at the midaspects of these surfaces.

Table 2. Distribution of surfaces according to residual probing depth (in mm) at 24 months and method of instrumentation

Die Verteilung der Oberflächen auf die Tiefe der Residualtaschen (in mm) nach 24 Monaten, sowie die instrumentale Behandlungsmethode

Répartition des surfaces suivant la profondeur résiduelle de poche après 24 mois et suivant la méthode d'instrumentation

Residual probing pocket depth (mm)	No. of surfaces	
	Hand instruments	Ultrasonics
1.0–1.5	27	37
2.0–2.5	84	75
3.0–3.5	121	125
4.0–4.5	90	82
5.0–5.5	44	59
6.0–6.5	39	26
7.0–7.5	17	12
8.0–8.5	4	7
9.0–9.5	—	1
10.0	—	2
Total	426	426

For the purpose of this study the records of examiner 1 have been used. The first of the 2 initial scores was used for the comparisons with the subsequent scores.

The intra- and interexaminer reproducibility of duplicate recordings before and after therapy is presented in a separate report (Badersten et al. 1984).

Results

Distribution of material

A total of 852 surfaces was treated. The distribution of these surfaces with respect to initial probing pocket depths and method of instrumentation is presented in Table 1. Similar distribution of surfaces with different pocket depths was present for hand and ultrasonic instruments. The average probing pocket depth was 5.7 mm for surfaces to be instrumented with either method.

Dental plaque

Initially, 59–86% of the tooth surfaces showed presence of plaque. At the 3-month examination the plaque scores were markedly reduced and remained low throughout the study. No differences were observed between surfaces treated by the 2 methods of instrumentation. However, the plaque scores of the patients instrumented by operator 2 remained somewhat higher throughout the study than those of operator 1 (Fig. 2).

Bleeding on probing

At the initial examination 84–90% of the surfaces demonstrated bleeding on probing. At the 3-month examination, 3 months after start of oral hygiene instruction and prior to instrumentation, the bleeding scores were minimally affected. Subsequent to instrumentation, a marked and gradual improvement of the bleeding scores took place until a 14–18% level was reached at 12 months. Similar reductions in bleeding scores occurred for both operators and both methods of instrumentation (Fig. 2).

Table 3. Residual probing depth (mean $\pm$ standard deviation) at the 24-month examination by initial pocket depth and method of instrumentation for operators 1 and 2. Pooled surfaces from all patients

Residuale Taschentiefe (Mittelwert $\pm$ Standarddeviation) bei der 2-Jahresuntersuchung in Bezug auf die initiale Taschentiefe und die instrumentale Behandlungsmethode, registriert vom Behandler 1 und 2. Zusammengefasste Werte aller Patienten

Profondeur résiduelle de poche (moyenne $\pm$ écart type) après 24 mois avec profondeur initiale de poche et méthode d'instrumentation pour les praticiens 1 et 2. Surfaces groupées de tous les patients

Initial probing pocket depth (mm)	Hand instruments		Ultrasonics	
	No. of surfaces	Depth at 24 months (mm)	No. of surfaces	Depth at 24 months (mm)
<i>Operator 1</i>				
4.0– 4.5	16	2.9 $\pm$ 1.2	17	3.3 $\pm$ 1.1
5.0– 5.5	42	3.7 $\pm$ 1.5	43	3.7 $\pm$ 1.2
6.0– 6.5	34	4.6 $\pm$ 1.5	32	4.1 $\pm$ 1.7
7.0– 7.5	30	4.7 $\pm$ 1.3	25	4.8 $\pm$ 1.6
8.0– 8.5	25	4.9 $\pm$ 1.6	22	6.0 $\pm$ 1.8
9.0– 9.5	15	5.1 $\pm$ 1.5	17	4.4 $\pm$ 1.2
10.0–10.5	6	4.2 $\pm$ 1.2	7	4.7 $\pm$ 1.7
11.0–11.5	4	6.2 $\pm$ 1.3	1	5.5 $\pm$ 0
<i>Operator 2</i>				
4.0– 4.5	15	3.2 $\pm$ 0.7	13	2.7 $\pm$ 0.6
5.0– 5.5	28	3.7 $\pm$ 1.5	23	3.5 $\pm$ 1.2
6.0– 6.5	45	4.1 $\pm$ 1.0	45	4.0 $\pm$ 1.1
7.0– 7.5	41	4.4 $\pm$ 1.1	44	4.1 $\pm$ 1.2
8.0– 8.5	19	4.1 $\pm$ 1.3	22	4.7 $\pm$ 1.2
9.0– 9.5	8	4.3 $\pm$ 1.5	8	5.3 $\pm$ 1.5
10.0–10.5	3	5.5 $\pm$ 1.3	4	4.7 $\pm$ 1.0
11.0–11.5	—	—	2	5.7 $\pm$ 0.3
12.0–12.5	—	—	2	5.2 $\pm$ 1.1

Table 4. Number of surfaces with probing pocket depth ≥ 7 mm and ≥ 6 mm, respectively, at initial examination and at 24 months by operator and method of instrumentation. Pooled data from all patients

Die Anzahl der Oberflächen mit sondierter Taschentiefe von ≥ 7 mm bzw. ≥ 6 mm, bei der Ausgangsuntersuchung und nach 24 Monaten, geordnet nach dem Behandler und nach der Methode instrumentaler Behandlung. Zusammengefasste Daten aller Patienten

Nombre de surfaces avec profondeur de poche ≥ 7 mm et ≥ 6 mm respectivement lors de l'examen initial et 24 mois après, par praticien et méthode d'instrumentation. Données groupées de tous les patients

	Operator 1		Operator 2		Operators 1 & 2	
	Hand instruments	Ultrasonics	Hand instruments	Ultrasonics	Hand instruments	Ultrasonics
Probing pocket depth ≥ 7 mm						
Initial	80	72	71	82	151	154
At 24 months	17	16	4	6	21	22
Probing pocket depth ≥ 6 mm						
Initial	114	104	116	127	230	231
At 24 months	43	31	17	17	60	48

Probing pocket depth

Initially, the mean probing pocket depths were 5.5–5.8 mm. 3 months after start of oral hygiene instruction the mean depths were reduced to 5.1–5.3 mm. Following instrumentation more noticeable reductions of pocket depths occurred until the depths stabilized around 3.6–3.9 mm at 12 months. Similar reductions took place for both operators and both methods of instrumentation (Fig. 2).

The distribution of the 852 experimental surfaces according to residual probing depth at 24 months and method of instrumentation is presented in Table 2. Similar distribution of surfaces with different residual probing depths was present for hand and ultrasonic instruments.

The residual probing depth at 24 months for pooled surfaces with initial probing pocket

depth ranging from 4.0–12.5 mm is shown in Table 3. Reduction of pocket depth took place also for the deeper pockets, irrespective of operator and method of instrumentation.

The number of surfaces with probing pocket depth ≥ 6 mm and ≥ 7 mm, respectively, at the initial examination and at 24 months is presented in Table 4. Initially, a total of 305 surfaces demonstrated probing pocket depth ≥ 7 mm. At the 24-month examination only 43 such surfaces remained.

Gingival recession

Limited gingival recession occurred during the initial 3 months of the study. Following instrumentation at 3 months, more notable recession took place until a level of 1.6–1.8 mm recession was reached at the 12-month examination (Fig. 2).

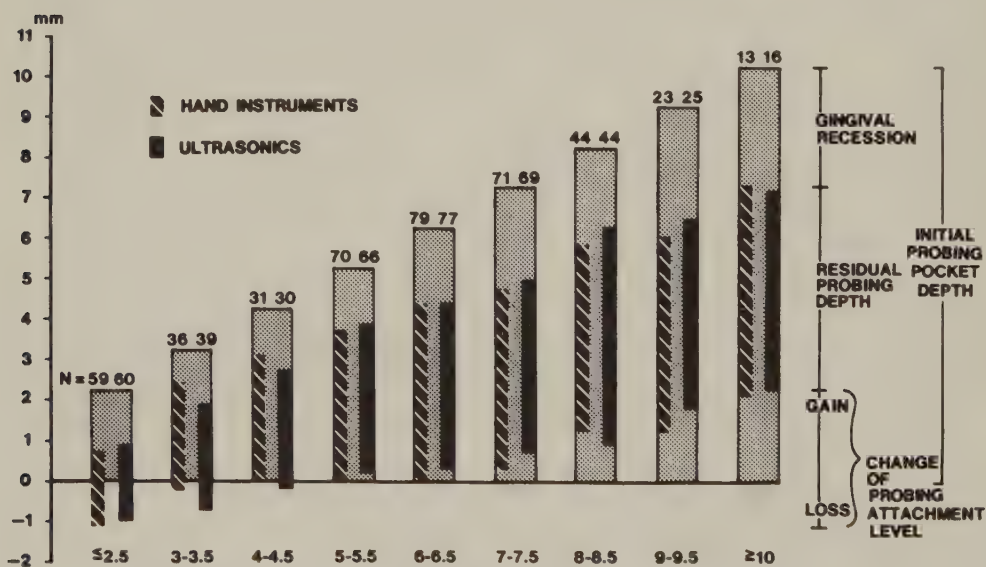


Fig. 3. Mean amounts of gingival recession, residual probing depth and gain/loss of probing attachment level at 24 months related to initial probing pocket depth. Pooled surfaces for hand and ultrasonic instruments from all patients.

Mittelwerte der gingivalen Rezession, der Residualtaschentiefe und des Gewinnes/Verlustes sondierten Attachmentniveaus nach 24 Monaten – in Bezug auf die Taschentiefe der Ausgangsuntersuchung. Zusammenfassung der durch Hand- und Ultraschall behandelten Oberflächen aller Patienten.

Quantités moyennes de récession gingivale, de profondeur résiduelle de poche et de variation de niveau d'attache après 24 mois, en relation avec la profondeur initiale de poche. Surfaces groupées pour les instruments manuels et les ultrasons pour tous les patients.

Probing attachment level

Limited changes in the mean probing attachment level occurred during the observation period. At 24 months a mean gain of probing attachment amounting to 0.1–0.3 mm was observed (Fig. 2).

Changes related to initial probing pocket depth

In Fig. 3 the data from all surfaces of all patients have been pooled and grouped according to initial probing pocket depth of the individual surfaces. Sites with initially deeper probing pocket depth showed more gingival recession, more gain of probing attachment and deeper residual probing depth at 24 months than sites with initial shallow pocket depth. Surfaces with initial probing pocket depth ≤ 3.5 mm demonstrated loss of probing attachment whilst surfaces initially ≥ 8 mm deep showed 0.9–2.3 mm average gain of probing attachment.

Similar healing events took place following both methods of instrumentation.

Computation of the data of Fig. 3 was also performed using patient means of surfaces of different initial probing pocket depths. These calculations showed average changes of the parameters similar to the pooled data of the individual surfaces.

Figs. 4, 5 and 6 present bleeding scores, probing pocket depths and changes in probing attachment levels at the 3-month recording intervals throughout the 24 months of study for surfaces with initial probing depth ≥ 7 mm. The sequential changes in these deep sites were similar irrespective of whether they were treated by operator 1 or 2, or by hand or ultrasonic instrumentation. Thus, the rate of initial healing was comparable and the results were equally well maintained once the improvements were obtained.

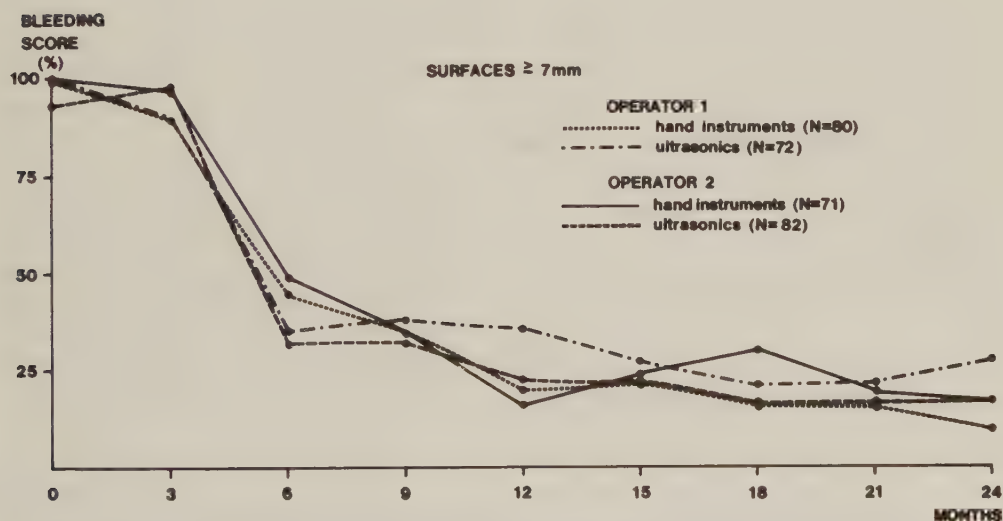


Fig. 4. Bleeding scores for surfaces with initial probing pocket depth ≥ 7 mm by operator and method of instrumentation at the 3-month recording intervals throughout the 24 months of study. N = number of available surfaces.

Blutungs Scores an Oberflächen mit einer initialen Sondierungstiefe von ≥ 7 mm, vom Behandler 1 und 2 registriert, sowie die Methode instrumentaler Behandlung während der in 3-monatlichen Abständen vorgenommenen Registrierungen, innerhalb der 24 Monate andauernden Studie. N = Anzahl zur Verfügung stehender Oberflächen.

Scores de saignement pour les surfaces avec profondeur initiale de poche ≥ 7 mm par praticien et méthode d'instrumentation lors des visites trimestrielles pendant les 2 années. N = nombre de surfaces disponibles.

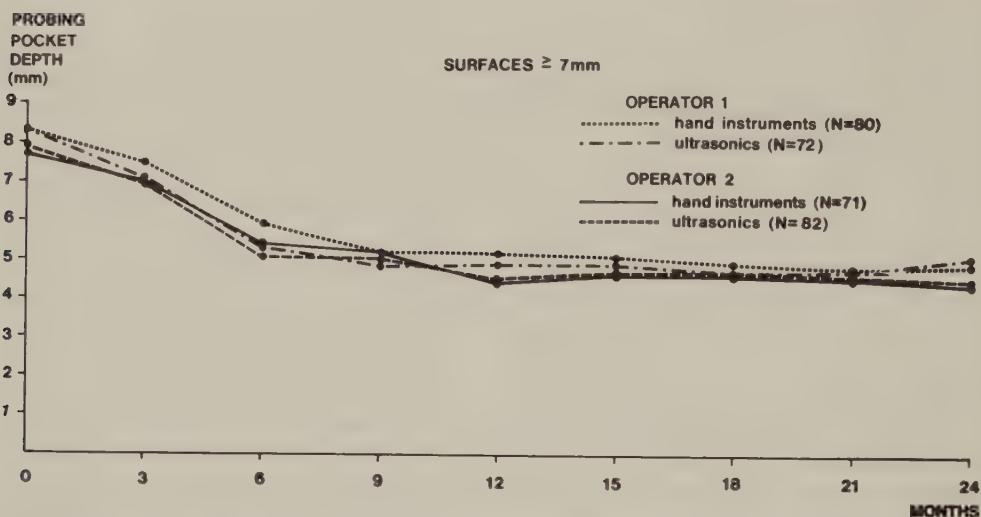


Fig. 5. Probing pocket depths for surfaces with initial probing pocket depth ≥ 7 mm by operator and method of instrumentation at the 3-month recording intervals throughout the 24 months of study. N=number of available surfaces.

Sondierte Taschentiefen an den Oberflächen einer, von jedem Behandler registrierten Taschentiefe von ≥ 7 mm, sowie die Methode instrumentaler Behandlung während der in 3-monatlichen Abständen vorgenommenen Registrierungen, innerhalb der 24 Monate andauernden Studie. N=Anzahl zur Verfügung stehender Oberflächen.

Profondeurs de poches pour les surfaces avec profondeur initiale ≥ 7 mm par praticien et méthode d'instrumentation lors des visites trimestrielles pendant les 2 années. N=nombre de surfaces disponibles.

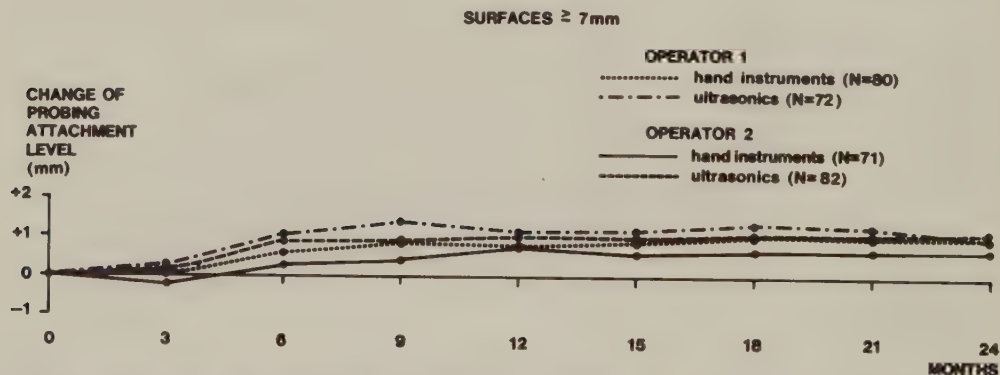


Fig. 6. Changes of probing attachment level for surfaces with initial probing pocket depth ≥ 7 mm by operator and method of instrumentation at the 3-month recording intervals throughout the 24 months of study. N=number of available surfaces.

Veränderungen des Attachmentniveaus an Oberflächen mit einer, von jedem Behandler registrierten, initialen Sondierungstiefe von ≥ 7 mm, sowie die Methode instrumentaler Behandlung während der in 3-monatlichen Abständen vorgenommenen Registrierungen, innerhalb der 24 Monate andauernden Studie. N=Anzahl der zur Verfügung stehenden Oberflächen.

Variations des niveaux d'attache pour les surfaces à profondeur initiale de poche ≥ 7 mm par praticien et par méthode d'instrumentation lors des visites trimestrielles pendant les 2 années. N=nombre de surfaces disponibles.

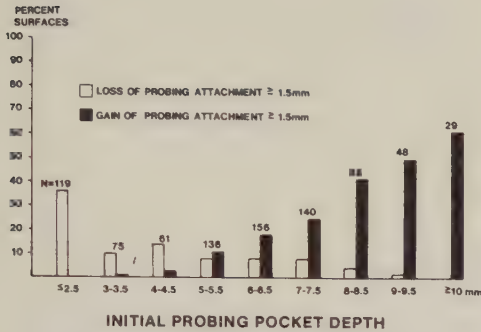


Fig. 7. Proportions (%) of surfaces with gain/loss of probing attachment level ≥ 1.5 mm at 24 months grouped by initial probing pocket depth. N=number of available surfaces.

Nach 24 Monaten – prozentualer Anteil von Oberflächen mit Gewinn/Verlust von Attachmentniveau von $\geq 1,5$ mm – gruppiert nach der initialen Sondierungstiefe. N=Anzahl der zur Verfügung stehenden Oberflächen.

Pourcentages de surfaces avec gain (colonnes noires) ou perte (colonnes blanches) d'attache $\geq 1,5$ mm après 24 mois, groupés par profondeur initiale. N=nombre de surfaces disponibles.

The proportion of surfaces with gain or loss of probing attachment level ≥ 1.5 mm at 24 months for surfaces with different initial probing pocket depths is presented in Fig. 7. Loss of probing attachment of this magnitude was encountered primarily for surfaces with initially shallow pockets whilst gain of attachment occurred for deep pockets. Only 5 out of all 165 sites initially ≥ 8 mm deep showed loss of probing attachment ≥ 1.5 mm, whilst 79 of the sites showed gain of probing attachment ≥ 1.5 mm.

Attachment changes as related to residual probing pocket depth

The mean changes in probing attachment level for pooled surfaces of different residual probing depths at 24 months are presented in Fig. 8. Surfaces ≤ 2.5 mm and ≥ 6 mm seemed to have lost a slight amount of probing attachment, whilst surfaces with a residual depth of 3.0–5.5 mm seemed to have undergone a minor improvement of attachment level.

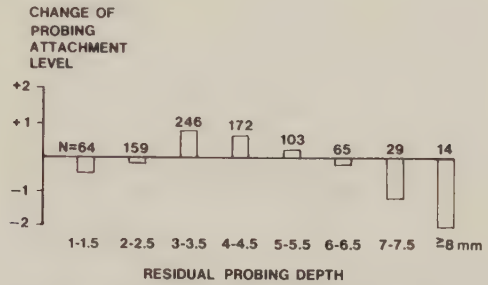


Fig. 8. Mean change of probing attachment level for surfaces with different residual probing depths at 24 months. Pooled surfaces from all patients. N= number of available surfaces.

Mittlere Veränderung des Attachmentniveaus an Oberflächen mit unterschiedlichen Tiefen residualer Taschen – nach 24 Monaten. Die Oberflächen aller Patienten sind zusammengefasst. N=Anzahl zur Verfügung stehender Oberflächen.

Variation moyenne du niveau d'attache de surfaces avec différentes profondeurs résiduelles de poche après 24 mois. Surfaces groupées de tous les patients. N=nombre de surfaces disponibles.

In Fig. 9 only surfaces demonstrating loss or gain of probing attachment ≥ 1.5 mm have been included. Loss of attachment of this magnitude primarily occurred for surfaces with a residual probing depth ≤ 2.5 mm and ≥ 6 mm. Gain of ≥ 1.5 mm attachment had taken place for 24–31% of surfaces with a residual probing depth between 3.0–4.5 mm.

Relationship of bleeding on probing and probing pocket depth

The proportion of bleeding surfaces at the initial examination was 90% or more for surfaces with initial probing pocket depth ≥ 4.0 mm (Fig. 10). At the 24-month examination the bleeding frequencies were markedly reduced not only for shallow pockets, but also for pockets of deep initial probing depth.

The bleeding frequencies at the 24-month examination according to residual probing depth are shown in Fig. 11. Bleeding upon probing was encountered more often in pockets with deeper residual probing depths than in shallow depths.

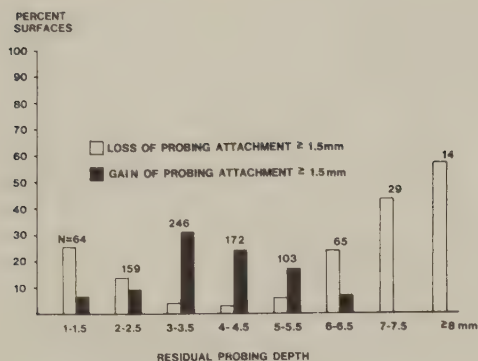


Fig. 9. Proportions (%) of surfaces with gain/loss of probing attachment level ≥ 1.5 mm at 24 months grouped by residual probing depth at 24 months. N=number of available surfaces.

Nach 24 Monaten - prozentualer Anteil der Oberflächen mit Gewinn/Verlust von Attachmentniveau ≥ 1.5 mm, gruppiert nach der residualen Taschentiefe nach 2 Jahren. N=Anzahl zur Verfügung stehender Oberflächen.

Pourcentages de surfaces avec gain (colonnes noires) ou perte (colonnes blanches) d'attache ≥ 1.5 mm après 24 mois, groupés par profondeur résiduelle de poche après 2 ans. N=nombre de surfaces disponibles.

Time of instrumentation

Mean time of instrumentation per tooth by operator and method of instrumentation is presented in Table 5. The total time of instrumentation varied to some degree between the 2 operators. Also, one of the operators used somewhat less time with ultrasonics than with hand instruments.

Discussion

The present study investigated the effects of oral hygiene instruction and supra- and subgingival instrumentation on severely advanced periodontitis and extended the observations made in our previous investigation performed on patients with moderately advanced periodontitis (Badersten et al. 1981). The findings demonstrated that nonsurgical therapy resulted in marked improvement of gingival conditions

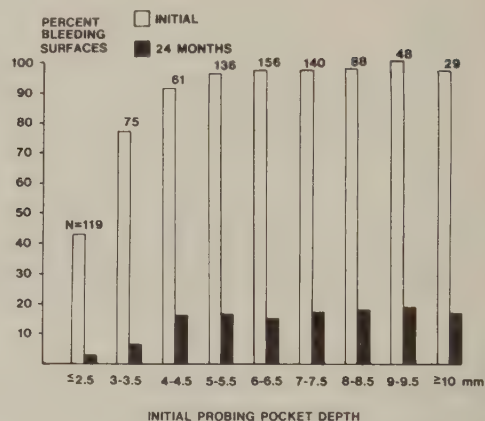


Fig. 10. Proportions (%) of surfaces showing bleeding upon probing at initial examination and at 24 months grouped by initial probing pocket depth. Pooled data from all patients. N=number of available surfaces.

Prozentualer Anteil der Oberflächen, die bei der Ausgangsuntersuchung und nach 24 Monaten beim Sondieren bluteten, gruppiert nach den initialen Taschentiefen. Zusammengefasste Daten aller Patienten. N=Anzahl zur Verfügung stehender Oberflächen.

Pourcentages de surfaces avec saignement au sondage lors de l'examen initial et après 24 mois, groupés par profondeur initiale de poche. Données groupées pour tous les patients. N=nombre de surfaces disponibles.

not only in periodontal pockets of moderate depth but also in pockets up to 12 mm deep.

Plaque control measures alone were instituted during the first 3 months of the study. Limited improvement occurred during this period in spite of the low plaque scores that were obtained. The mean probing pocket depths were reduced by 0.4–0.5 mm, primarily due to gingival recession. Minimal improvement of bleeding scores was observed. These limited changes were contrasted to the improvement that took place during the subsequent 3 months following start of instrumentation. During this period probing depths were further reduced by 0.9–1.2 mm together with marked improvement in bleeding scores. The limited improvement following plaque control alone is in agreement with the findings of Cercek et al. (1983) investigating the effect of prolonged plaque control measures.

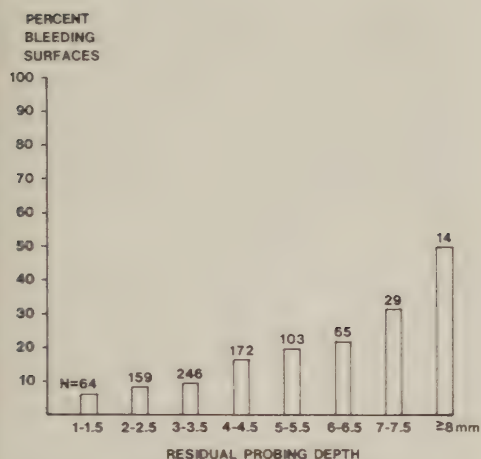


Fig. 11. Proportions (%) of surfaces showing bleeding upon probing at 24-month examination grouped by residual probing depth at 24 months. Pooled data from all patients. N=number of available surfaces.

Prozentualer Anteil der Oberflächen, die bei der Ausgangsuntersuchung und nach 24 Monaten beim Sondieren bluteten, gruppiert nach den residualen Taschentiefen. Zusammengefasste Daten aller Patienten. N=Anzahl zur Verfügung stehender Oberflächen.

Pourcentages de surfaces avec saignement au sondage lors de l'examen après 24 mois, groupés par profondeur résiduelle de poche après 24 mois. Données groupées de tous les patients. N=nombre de surfaces disponibles.

Periodontal conditions continued to improve during 6-9 months following start of instrumentation. In our previous study (Badersten et al. 1981) the improvement leveled off after

3-4 months. The discrepancies in results between these 2 investigations are most likely explained by the differences of the subjects under study. The more advanced disease with deeper pockets of the present study continued to improve during a longer period than the less advanced lesions of the previous study.

Again, similar to the studies by Torfason et al. (1979) and Badersten et al. (1981), no differences in results could be detected following hand and ultrasonic instrumentation. Debridement of the contaminated root surfaces in deep pockets can apparently be accomplished by ultrasonics as well as hand instruments. Also, as in the study by Badersten et al. (1981), the 2 participating operators obtained comparable results.

Most of the examined surfaces showed bleeding on probing at the initial examination. The therapy resulted in substantial reduction of the bleeding scores including sites with deep initial probing pocket depths. Some surfaces, however, still showed bleeding after treatment. The proportion of bleeding surfaces after therapy was higher for surfaces with deeper residual probing depths than for surfaces with shallow residual depths. At 24 months, 31% of the surfaces with 7-7.5 mm and 50% of the surfaces with ≥ 8.0 mm residual probing depth bled upon probing. However, 9-16% of surfaces with 3.0-4.5 mm residual probing

Table 5. Mean time of instrumentation (min per tooth) by operator and method of instrumentation

Mittlerer Zeitverbrauch des Behandlers bei der instrumentalen Behandlung (in Min pro Zahn) und die Methode der instrumentalen Behandlung

Durée moyenne d'instrumentation (en minutes par dent) par praticien et méthode d'instrumentation

	Operator 1		Operator 2	
	Hand instruments	Ultra-sonics	Hand instruments	Ultra-sonics
Instrumentation No. 1 (at 3 months)	5.7	4.9	8.0	8.8
Instrumentation No. 2 (at 6 months)	2.7	1.8	2.9	2.7
Instrumentation No. 3 (at 9 months)	1.0	0.9	1.6	1.8
Total	9.4	7.6	12.5	13.3

depth also showed bleeding on probing at this point.

The probing pocket depths of sites initially 7.0–12.5 mm deep were markedly reduced following the conservative therapeutic approach. The probing attachment levels were also improved. More mean pocket reduction and gain of attachment was obtained for these deep sites than for surfaces with 4.0–6.5 mm initial depth. Similar patterns of change in probing pocket depths and probing attachment levels following nonsurgical therapy have been reported by Hill et al. (1981), Isidor (1981), Pihlstrom et al. (1981) and Lindhe et al. (1982a, b). Thus, the fact that deep pockets show more gain of probing attachment than moderately deep pockets combined with the fact that they demonstrate similar reduction of bleeding upon probing indicate that there is no certain magnitude of initial probing pocket depth where nonsurgical periodontal therapy is no longer effective. Our observations further suggest that the decision to proceed with additional therapy should preferably be postponed until 6–9 months after start of instrumentation. Not until then has all the healing taken place that will occur following nonsurgical therapy.

Loss of probing attachment level was primarily observed for sites with initial shallow probing pocket depth. Attachment loss following nonsurgical therapy has previously been reported for shallow sites and buccal surfaces by Badersten et al. (1981), Hill et al. (1981), Isidor (1981), Pihlstrom et al. (1981) and Lindhe et al. (1982a, b). Interestingly, Cercek et al. (1983) also found some loss of probing attachment at sites with shallow probing depth following plaque control measures alone (without concomitant instrumentation). It was suggested that the attachment loss for shallow sites may be related not only to injury from instrumentation but also to some type of atrophy, possibly caused by tooth brushing trauma.

The present study does not provide any

information on the response of molars to nonsurgical therapy, since these teeth were excluded from observation. Recent reports by Lindhe et al. (1982a, b), however, indicate that healing events in molars are similar to the healing of incisors, cuspids and premolars. Although their results indicate a tendency towards more pocket reduction and gain of probing attachment in incisors, cuspids and premolars as compared to molars, these differences did not appear to be statistically significant. The similarity of response in molars, as reported by Lindhe and coworkers, may be related to the fact that the majority of the molar sites under study in their investigation were pockets adjacent to "flat" surfaces. No study seems available as yet where special attention has been focused on the response of molar sites with furcation involvement.

Instrumentations were carried out at 3, 6 and 9 months. Thereafter, plaque control and tooth polishing only were performed. Thus, during a 15-month interval between the 9- and 24-month examinations, there was no subgingival instrumentation. The means of all periodontal parameters remained unchanged during this interval. This included sites with initial probing pocket depth ≥ 7 mm. This apparently successful maintenance indicates that supra-gingival plaque control combined with polishing was sufficient to prevent subgingival recolonization by microorganisms to the extent that relapse occurred. Analyses of results, in this report limited to observations of means of the various parameters, however, do not disclose if occasional surfaces may have deteriorated.

Several other questions remain to be answered before further recommendations for clinical purposes can be given. For example, the present study utilized repeated instrumentation at 3-month intervals. Would comparable improvements occur after a single, initial instrumentation only? Also, this report is limited to a 24-month observation period. Will results continue to hold up beyond this period

with a maintenance program? Furthermore, in spite of the overall successful results some sites appeared to show progression of the disease. What are the characteristics of these sites? Would these sites have responded more favorably if periodontal surgery had been used?

Acknowledgements

Sincere thanks are due to Gunvor Johansson, Inger Franklin and Gunilla Larsson for dental hygiene therapy, to Berit Grankvist for secretarial assistance and to William Pote and Paul Yahiko, Ph. D., for statistical analyses.

Zusammenfassung

Der Effekt nicht-chirurgischer Parodontaltherapie II. Weit fortgeschrittene Parodontitis

Bei Patienten mit parodontalen Taschen bis zu 12 mm Tiefe, wurden die Heilungsvorgänge nach nicht-chirurgischer Parodontaltherapie untersucht. Schneidezähne, Eckzähne und Prämolaren wurden bei 16 Patienten mittels Plaquekontrolle, sowie mit supra- und subgingivaler Zahnsteinbehandlung mit Hand- oder Ultraschallinstrumenten, im "splitmouth"-Versuchsansatz behandelt. Die Resultate wurden durch das Registrieren der Plaque-Scores (Beurteilungseinheiten), der Blutungstendenz nach dem Sondieren, sowie durch das Sondieren der Taschentiefen und des Attachmentniveaus ausgewertet. Während der ersten 3 Versuchsmonate wurde lediglich Plaquekontrolle vorgenommen und die Veränderungen des gingivalen Erscheinungsbildes waren minimal. Nach instrumenteller Behandlung und im Laufe der dann folgenden 9 Monate kam es zu schrittweiser und markanter Verbesserung der parodontalen Verhältnisse. Während der dann noch verbleibenden 12 Monate der 24-monatlichen Versuchsperiode wurden keine weiteren Veränderungen der erreichten Behandlungsergebnisse gesehen. Beim Vergleich zwischen den therapeutischen Resultaten der Hand- und der Ultraschallinstrumente, wie auch bei dem Vergleich der Behandlungsergebnisse 2 verschiedener Behandler, konnte kein Unterschied festgestellt werden. Anfangs wurde an 305 sondierten Zahnoberflächen eine Taschentiefe von ≥ 7 mm festgestellt. Bei der Nachuntersuchung nach 24 Monaten waren nur noch 43 Zahnoberflächen mit diesen Taschentiefen vorhanden. Die vorliegenden Resultate zeigen, dass es keine spezielle Sondierungstiefe gibt, bei der nicht-chirurgische Parodontaltherapie nicht mehr wirkungsvoll und damit sinnvoll ist.

Résumé

Effet du traitement parodontal non-chirurgical II. Parodontite très sévère

La guérison de 16 patients ayant subi un traitement parodontal non-chirurgical et dont la profondeur des poches parodontales atteignait jusqu'à 12 mm a été observée. Des incisives, canines et prémolaires ont été traitées par contrôle de plaque dentaire et détartrage sus- et sousgingival aux ultrasons pour la moitié des dents et avec des instruments manuels pour l'autre moitié. Les résultats ont été évalués en enregistrant les scores de plaque, le saignement au sondage, les profondeurs de poche et les niveaux d'attache. Durant les 3 premiers mois de l'expérience seules les mesures d'hygiène buccale ont été prises et les conditions gingivales ont peu varié. Après l'instrumentation et durant les 9 mois suivants, une nette amélioration progressive de l'état du parodonte était constatée. Durant les 12 derniers mois de cette expérience de 2 ans, aucun changement supplémentaire n'a été enregistré. Ni les résultats obtenus avec les ultrasons ou avec les instruments manuels, ni ceux enregistrés par les 2 praticiens ne présentaient de différence. Au départ, 305 sites avaient une profondeur de poche de ≥ 7 mm. Deux années plus tard, il n'en restait plus que 43. Les résultats indiquent qu'aucune profondeur initiale de poche ne limite la thérapie parodontale non chirurgicale.

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Paper II

Effect of nonsurgical periodontal therapy

III. Single versus repeated instrumentation

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Abstract. Healing events following nonsurgical periodontal therapy were studied, comparing the effect of a single initial instrumentation to the effect of 3 instrumentations, each separated by 3 months. Incisors, cuspids and premolars with periodontal pockets up to 11 mm deep in 13 patients were treated by plaque control and supra- and subgingival debridement using ultrasonic instruments. A split mouth approach was used to compare the 2 frequencies of instrumentation. The results were evaluated by recording of plaque scores, bleeding on probing, probing pocket depths and probing attachment levels. A gradual and marked improvement of the periodontal conditions took place during the initial 9 months following start of therapy. During the remaining 15 months of the 24-month experimental period no further changes of the recorded parameters were noted. No differences in results could be observed when comparing the effects of a single versus repeated instrumentation. Thus, it appears that deep periodontal pockets in incisors, cuspids and premolars may be successfully treated by plaque control and 1 episode of instrumentation. The results also suggest that recurrence of disease due to subgingival recolonization by microorganisms during the healing phase may not be a major clinical problem.

In 2 previous studies we investigated the effect of nonsurgical periodontal therapy in patients with moderately and severely advanced periodontitis (Badersten et al. 1981, 1983a). Substantial improvement of periodontal conditions was accomplished. The instrumentation in these studies was performed at 3 visits, each separated by 2–4 months.

It is possible that the apparently successful results obtained in our previous studies were related to the time and effort spent on repeated instrumentation. Optimal results following conservative treatment of deep periodontal pockets may require repeated instrumentation to ensure complete debridement of plaque, calculus and root surface contaminants and to remove subgingival plaque that may have recolonized the root surface in the period between instrumentations. The present study was de-

signed to investigate this problem. Patients with severely advanced periodontitis and periodontal pockets up to 11 mm deep were treated with oral hygiene instruction and supra- and subgingival debridement using a split mouth approach comparing the effect of a single initial instrumentation to 3 instrumentations, each separated by 3 months.

Material and Methods

13 patients, 30–55 years of age, 7 males and 6 females with severely advanced periodontal disease, were selected for the study. Incisors, cuspids and premolars in either the maxilla or the mandible were studied. A minimum of 6 and a maximum of 10 teeth were used in each patient. The areas of the dentition under study had generalized periodontal destruction involv-

EXPERIMENTAL DESIGN

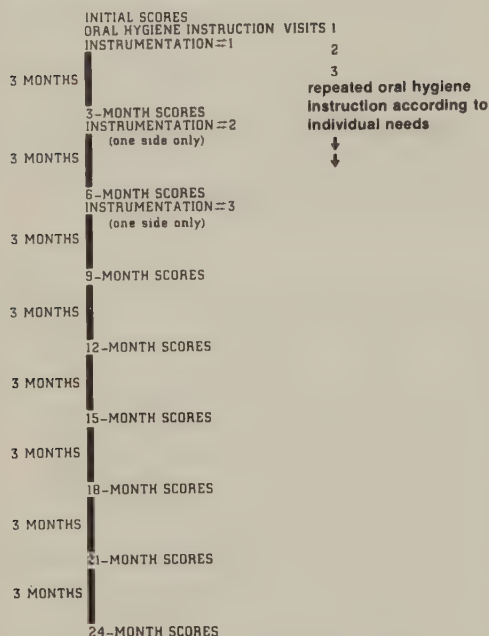


Fig. 1. Flow chart of the experimental design.

Versuchsablauf - Zeitfolge.

Organigramme du plan de l'expérience.

ing both sides of the jaw to a similar extent. Clinical signs of gingival inflammation and periodontal pockets ≥ 5 mm deep with calculus and bleeding on probing were present on 2 or more aspects of each tooth.

The therapy and methods of the present investigation were similar to those of Badersten et al. (1981) with the exceptions described below.

The experimental design is shown in Fig. 1.

Oral hygiene instruction

Oral hygiene instruction was given in 2-3 visits during the first month of experimentation. Additional instruction, reinforcement and rubber-cup polishing of the teeth was provided according to individual needs for the entire duration of the study.

Debridement of periodontal pockets

Instrumentation was carried out by 1 operator (author J.E.) using ultrasonic instruments and started immediately following the initial examination. The teeth of the right and left sides of the jaw were randomly assigned to 1 or 3 instrumentations. Repeated instrumentation in one side of the jaw was performed after 3 and 6 months.

Methods of measurement

The results of the treatment were evaluated by measurements of dental plaque, bleeding on probing, probing pocket depth, probing attachment level and gingival recession. Recordings were made at the initial examination and subsequently every third month by one of the authors (A.B.) who was unaware of which side of the jaw had been instrumented 1 or 3 times. Recordings were made at 6 aspects of each tooth: mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual.

At the initial recording and at 18 and 24 months, a second examiner (author R.N.) also measured probing pocket depth and probing attachment level for the purpose of studying interexaminer reproducibility of the recordings.

The probing measurements were taken after the recording of plaque and bleeding scores.

Bleeding on probing

Bleeding on probing was determined by means of an electronic pressure sensitive probe (Electronic Periodontal Probe, model 200, Vine Valley Research, Middlesex, NY, U.S.A.) with a specially machined and calibrated probe tip (0.5 mm in diameter, 1 mm increments). A positive score was recorded if hemorrhage was noted subsequent to a single probing of each site using a probing force of 0.75 N.

Probing pocket depth and probing attachment level

Probing pocket depths and probing attachment levels were measured to the nearest of half a mm with the electronic pressure sensitive probe and

0.75 N probing force. The margins of soft acrylic onlays were used to provide reference points for the attachment level measurements (Drufosoft, Dreve, Unna, West Germany). Steering grooves were not made in the onlays. The proximal placement of the probe was guided by the interdental indentations on the thin onlay and the probe was directed apically at a slight angle to the long axis of the tooth. The buccal and lingual measurements were made at the midaspects of these surfaces.

The interexaminer reproducibility of duplicate recordings before and after therapy is presented in a separate report (Badersten et al. 1983b).

Results

Distribution of material

A total of 624 surfaces was treated. The distribution of these surfaces with respect to initial probing pocket depth and frequency of instrumentation is presented in Table 1. Similar

Table 1. Distribution of surfaces by initial probing pocket depth (in mm) and frequency of instrumentation

Verteilung der Oberflächen nach initialer Sondierungstiefe (in mm) und Häufigkeit instrumentaler Behandlung

Distribution de surfaces par profondeur initiale de poche (en mm) et par fréquence d'instrumentation

Initial probing pocket depth (mm)	No. of surfaces	
	1 instrumen- tation	3 instrumen- tations
1.0- 1.5	4	1
2.0- 2.5	30	33
3.0- 3.5	27	25
4.0- 4.5	25	31
5.0- 5.5	56	58
6.0- 6.5	66	54
7.0- 7.5	52	52
8.0- 8.5	29	30
9.0- 9.5	12	14
10.0-10.5	6	10
11.0-11.5	5	4
Total	312	312

distribution of surfaces with different pocket depths was present for 1 and 3 instrumentations. The average probing pocket depth was 5.8 mm for surfaces to be instrumented once and 5.9 mm for surfaces to be treated 3 times.

Dental plaque

Initially, 78-82% of the tooth surfaces showed presence of plaque. After 3 months the plaque scores were significantly reduced and remained low throughout the study. Similar reductions were observed for surfaces treated by the 2 different frequencies of instrumentation (Fig. 2).

Bleeding on probing

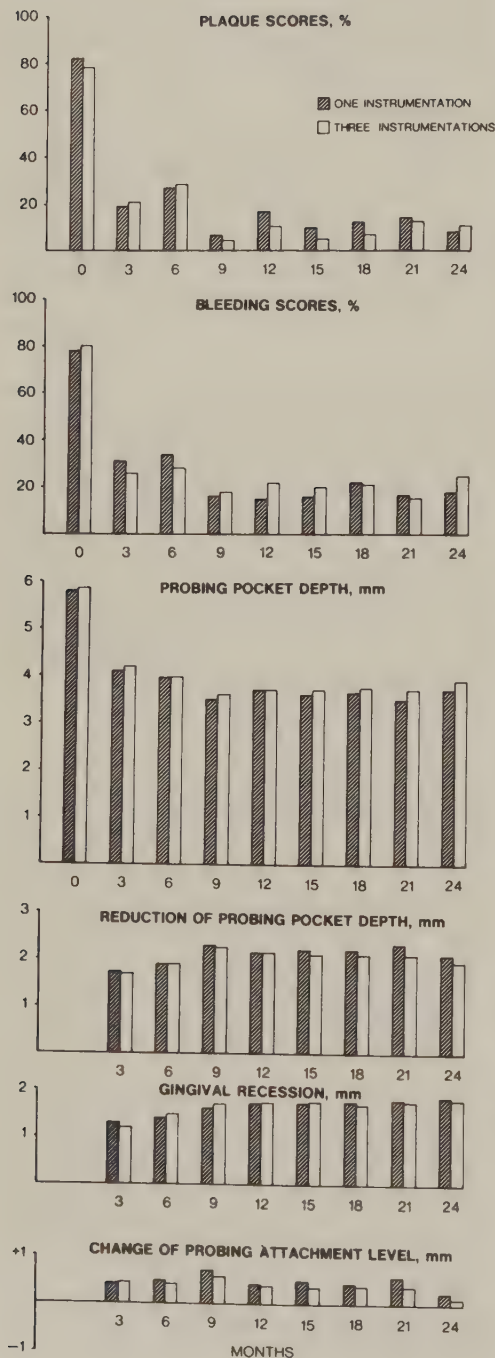
At the initial examination 78-80% of the surfaces showed bleeding upon probing. At the 3-month examination, 3 months after start of oral hygiene instruction and instrumentation, the bleeding scores were reduced to 26-31%. A further reduction took place until a 15-20% level was reached, which was maintained during the entire observation period. Similar reductions in bleeding scores took place for the 2 frequencies of instrumentation.

Probing pocket depth

Initially, the mean probing pocket depths for all 6 surfaces of the teeth were 5.8-5.9 mm. 3 months after start of oral hygiene instruction and instrumentation, the mean pocket depths were reduced to 4.1-4.2 mm. A further reduction took place until the 9-month examination when the depths stabilized around 3.5-3.7 mm. Similar reductions took place for the 2 different frequencies of instrumentation (Fig. 2).

The distribution of the 624 experimental surfaces according to residual probing depth at 24 months and frequency of instrumentation is presented in Table 2. Similar distribution of surfaces with different residual probing depths was present for surfaces instrumented 1 or 3 times.

The number of surfaces with probing pocket depth ≥ 6 mm and ≥ 7 mm, respectively, at the



initial examination and at 24 months is presented in Table 3. Initially a total of 214 surfaces demonstrated probing pocket depth ≥ 7 mm. At the 24-month examination only 32 such surfaces remained. Similar results were obtained for the 2 frequencies of instrumentation.

Gingival recession

Mean gingival recession for all surfaces at the 24-month examination was 1.8 mm. Most of the recession took place during the initial 9 months of the study (Fig. 2).

Probing attachment level

A mean gain of probing attachment level amounting to about 0.4 mm was observed after 3 months and was maintained during the course of the study (Fig. 2).

Changes related to initial probing pocket depth

In Fig. 3 the data from all surfaces of all patients have been pooled and grouped according to initial probing pocket depth of the individual surfaces. Sites with initially deeper probing pocket depth showed more gingival recession, more gain of probing attachment and deeper residual probing depth at 24 months than sites with initial shallow pocket depth. Sites with initial probing pocket depth ≤ 3 mm demonstrated 0.4–1.0 mm average loss of probing attachment, whilst sites initially ≥ 8 mm deep showed 0.9–2.8 mm average gain of probing attachment. Similar healing events took place following both frequencies of instrumentation.

Fig. 2. Means of the recorded parameters by frequency of instrumentation at the 3-month recording intervals throughout the 24 months of study.

Mittelwerte der registrierten Parameter. Die Werte wurden je nach der Häufigkeit der instrumentalen Behandlung geordnet. Während der 2 Jahre andauernden Studie wurde die Registrierung der Parameter in 3-monatlichen Abständen vorgenommen.

Moyennes des paramètres enregistrés par fréquence d'utilisation des ultrasons (colonnes hachurées=1 instrumentation, colonnes vides=3 instrumentations) lors des visites trimestrielles échelonnées sur 2 ans.

Table 2. Distribution of surfaces according to residual probing depth (in mm) at 24 months and frequency of instrumentation

Die Verteilung der Oberflächen je nach dem Vorkommen der nach 24 Monaten noch vorhandenen Residualtaschentiefen (in mm) und nach der Häufigkeit instrumentaler Behandlung

Distribution de surfaces par profondeur résiduelle de poche (en mm) après 24 mois, et par fréquence d'instrumentation

Residual probing pocket depth (mm)	No. of surfaces	
	1 instrumentation	3 instrumentations
1.0-1.5	25	26
2.0-2.5	53	51
3.0-3.5	78	71
4.0-4.5	79	80
5.0-5.5	40	34
6.0-6.5	22	33
7.0-7.5	11	11
8.0-8.5	4	6
Total	312	312

Table 3. Number of surfaces with probing pocket depth ≥ 7 mm and ≥ 6 mm, respectively, at initial examination and at 24 months by frequency of instrumentation. Pooled data from all patients

Die Anzahl der Oberflächen mit sondierter Taschentiefe von ≥ 7 mm bzw. ≥ 6 mm bei der Ausgangsuntersuchung und nach 24 Monaten, geordnet nach der Häufigkeit instrumentaler Behandlung. Zusammenfassung der Daten aller Patienten

Nombre de surfaces avec profondeur de poche ≥ 7 mm et ≥ 6 mm respectivement lors de l'examen initial et 24 mois après, par fréquence d'instrumentation. Données groupées de tous les patients

	1 instrumentation	3 instrumentations
Probing pocket depth ≥ 7 mm		
Initial	104	110
At 24 months	15	17
Probing pocket depth ≥ 6 mm		
Initial	170	164
At 24 months	37	50

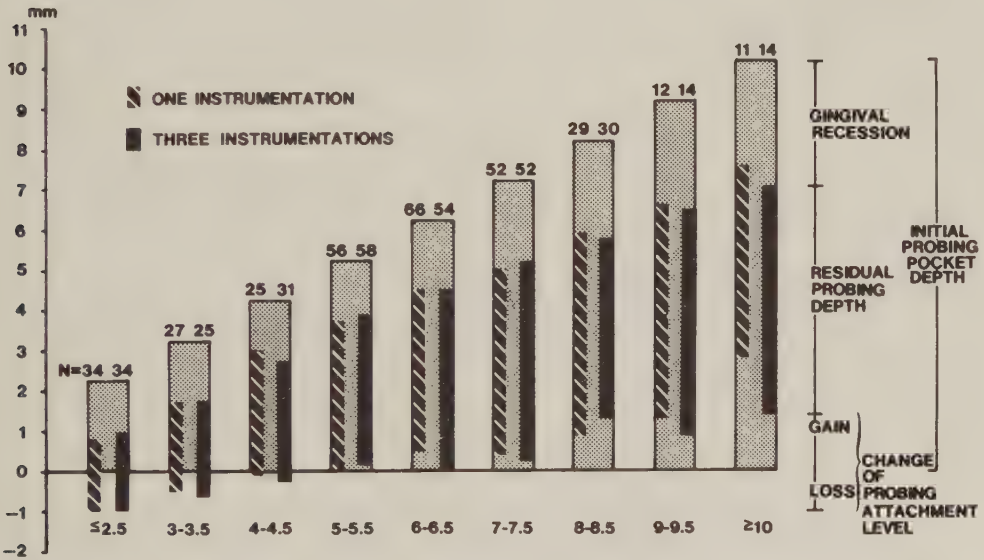


Fig. 3. Mean amounts of gingival recession, residual probing depth and gain/loss of probing attachment level at 24 months related to initial probing pocket depth. Pooled surfaces for 1 and 3 instrumentations from all patients.

Mittelwerte der gingivalen Rezession, der Residualtaschentiefe und des Gewinnes/Verlustes sondierten Attachmentniveaus nach 24 Monaten – in Bezug auf die Taschentiefe der Ausgangsuntersuchung. Zusammenfassung der Oberflächen von allen Patienten mit 1 und 3-maliger instrumentaler Behandlung.

Quantités moyennes de récession gingivale, de profondeur résiduelle de poche et de variation de niveau d'attache après 24 mois, en relation avec la profondeur initiale de poche. Surfaces groupées pour l'instrumentation unique (colonnes hachurées) et triple (colonnes noires) pour tous les patients.

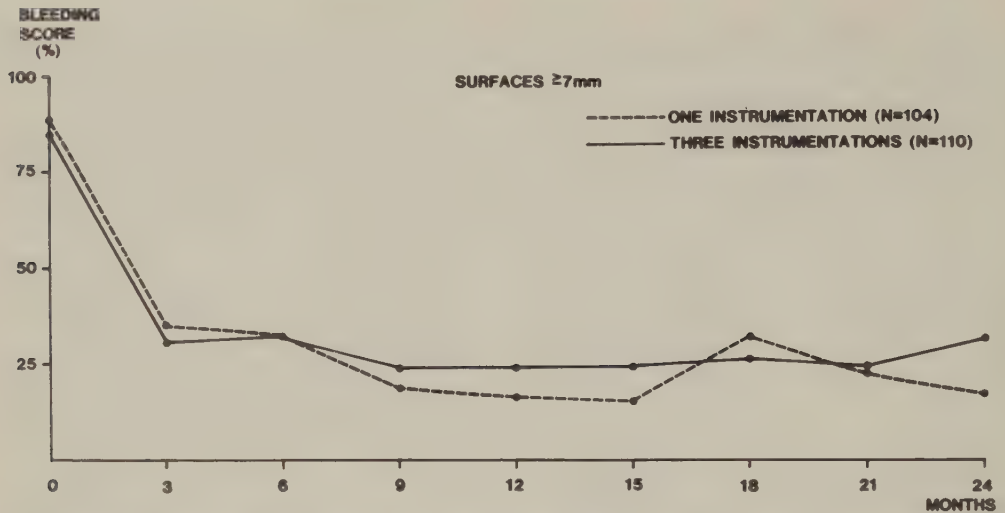


Fig. 4. Bleeding scores for surfaces with initial probing pocket depth ≥ 7 mm by frequency of instrumentation at the 3-month recording intervals throughout the 24 months of study. N=number of available surfaces.

Blutungs-Scores an Oberflächen mit einer initialen Sondierungstiefe von ≥ 7 mm, je nach der Häufigkeit der instrumentalen Behandlung. Während der 24 Monate wurde in 3-monatlichen Abständen registriert. N=Anzahl zugänglicher Oberflächen.

Scores de saignement pour les surfaces avec profondeur initiale de poche ≥ 7 mm par fréquence d'instrumentation lors des visites trimestrielles échelonnées sur 2 ans. N=nombre de surfaces disponibles.

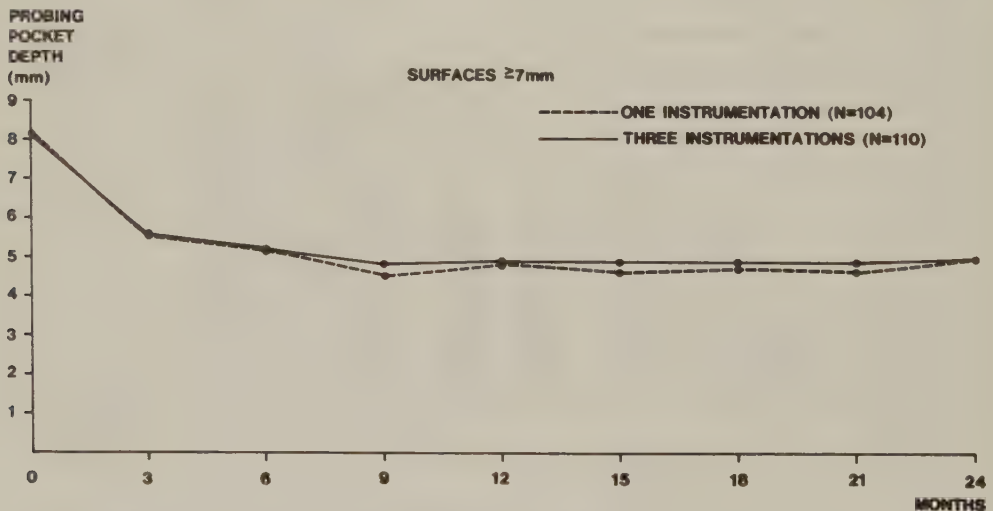


Fig. 5. Probing pocket depths for surfaces with initial probing pocket depth ≥ 7 mm by frequency of instrumentation at the 3-month recording intervals throughout the 24 months of study. N=number of available surfaces.

Taschentiefen an Oberflächen mit einer initialen Sondierungstiefe von ≥ 7 mm, je nach Häufigkeit instrumentaler Behandlung. Während der 2-Jahresstudie wurde in 3-monatlichen Abständen registriert. N=Anzahl zugänglicher Oberflächen.

Profondeurs de poche pour les surfaces avec profondeur initiale ≥ 7 mm par fréquence d'instrumentation lors des visites trimestrielles échelonnées sur 2 ans. N=nombre de surfaces disponibles.

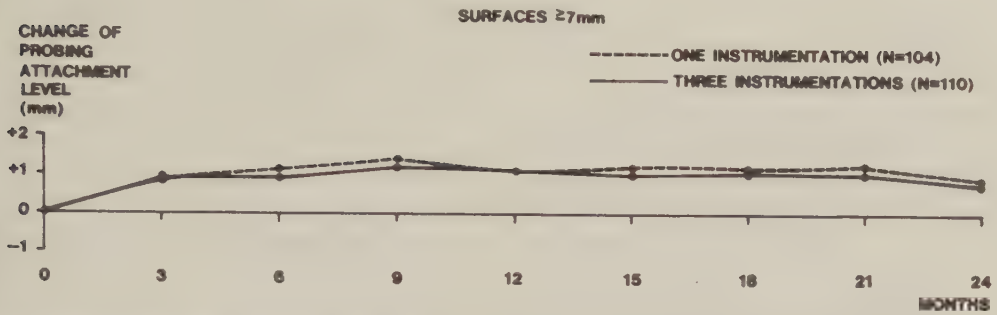


Fig. 6. Changes of probing attachment level for surfaces with initial probing pocket depth ≥ 7 mm by frequency of instrumentation at the 3-month recording intervals throughout the 24 months of study. N=number of available surfaces.

Veränderungen des Attachmentniveaus an Oberflächen mit einer initialen Sondierungstiefe von ≥ 7 mm, je nach Häufigkeit instrumentaler Behandlung. Während der 2-Jahresstudie wurde in 3-monatlichen Abständen registriert. N=Anzahl zugänglicher Oberflächen.

Variations de niveau d'attache pour les surfaces dont la profondeur initiale ≥ 7 mm par fréquence d'instrumentation lors des visites trimestrielles échelonnées sur 2 ans. N=nombre de surfaces disponibles.

Computation of the data of Fig. 3 was also performed using patient means of surfaces of different initial probing pocket depths. These calculations showed average changes of the parameters similar to the pooled data of the individual surfaces.

Figs. 4, 5 and 6 present bleeding scores, probing pocket depths and changes in probing attachment levels at the 3-month recording intervals throughout the 24 months of study for surfaces with initial probing pocket depth ≥ 7 mm. The sequential changes of these deep sites were similar for both frequencies of instrumentation. Thus, the rate of initial healing was the same for sites instrumented once only and sites instrumented 3 times. Also, the results were equally well maintained once the improvement was obtained.

The proportion of surfaces with gain or loss of probing attachment level ≥ 1.5 mm at 24 months for surfaces with different initial probing pocket depths is presented in Fig. 7. Loss of probing attachment of this magnitude was observed primarily for surfaces with initially shallow pockets whilst gain of attachment occurred for deep pockets. Only 4 out of all 110

sites initially ≥ 8 mm deep showed loss of probing attachment ≥ 1.5 mm, whilst 53 of the sites showed gain of probing attachment ≥ 1.5 mm.

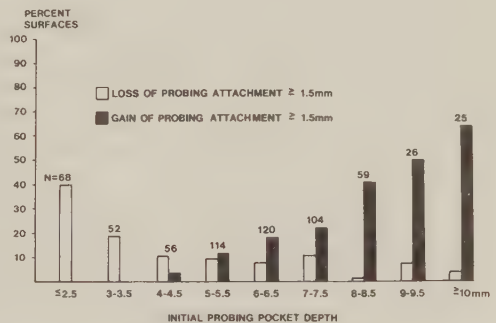


Fig. 7. Proportions (%) of surfaces with gain/loss of probing attachment level ≥ 1.5 mm at 24 months grouped by initial probing pocket depth. N=number of available surfaces.

Prozentuales Vorkommen von Oberflächen mit einem Gewinn/Verlust von $\geq 1,5$ mm Attachmentniveau nach 24 Monaten – gruppiert je nach der initialen Sondierungstiefe. N=Anzahl zur Verfügung stehender Oberflächen.

Pourcentages de surfaces avec gain (colonnes noires) ou perte (colonnes blanches) d'attache $\geq 1,5$ mm après 24 mois, groupés par profondeur initiale. N=nombre de surfaces disponibles.

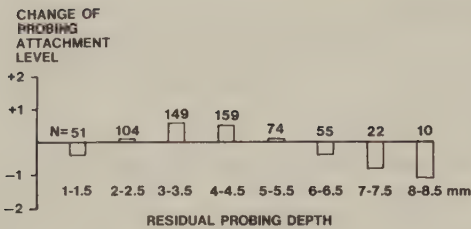


Fig. 8. Mean change of probing attachment level for surfaces with different residual probing depths at 24 months. Pooled surfaces from all patients. N=number of available surfaces.

Mittlere Veränderung des Attachmentniveaus an Oberflächen mit unterschiedlichen Tiefen residueller Taschen, nach 24 Monaten. Die Oberflächen aller Patienten sind zusammengefasst. N=Anzahl zur Verfügung stehender Oberflächen.

Variation moyenne du niveau d'attache de surfaces avec différentes profondeurs résiduelles de poches après 24 mois. Surfaces groupées de tous les patients. N=nombre de surfaces disponibles.

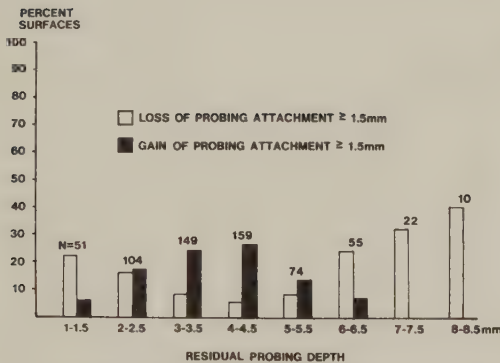


Fig. 9. Proportions (%) of surfaces with gain/loss of probing attachment level ≥ 1.5 mm at 24 months grouped by residual probing depth at 24 months. N=number of available surfaces.

Nach 24 Monaten – prozentualer Anteil der Oberflächen mit Gewinn/Verlust von Attachmentniveau von $\geq 1,5$ mm – gruppiert nach der residuellen Taschentiefe nach 2 Jahren. N=Anzahl zur Verfügung stehender Oberflächen.

Pourcentages de surfaces avec gain (colonnes noires) ou perte (colonnes blanches) d'attache $\geq 1,5$ mm après 24 mois, groupés par profondeur résiduelle de poche après 2 ans. N=nombre de surfaces disponibles.

Attachment changes as related to residual probing pocket depth

The mean changes in probing attachment level for pooled surfaces of different residual probing depths at 24 months are presented in Fig. 8. Surfaces with residual depth ≤ 1.5 mm and ≥ 6 mm seemed to have lost some probing attachment, whilst surfaces with a residual depth of 3.0–5.5 mm seemed to have undergone a minor improvement of attachment level.

In Fig. 9 only surfaces demonstrating loss or gain of probing attachment ≥ 1.5 mm have been included. Loss of attachment of this magnitude occurred primarily for surfaces with a residual probing depth ≤ 2.5 mm and ≥ 6 mm. Gain of ≥ 1.5 mm attachment took place for 24–26% of surfaces with a residual probing depth between 3.0–4.5 mm.

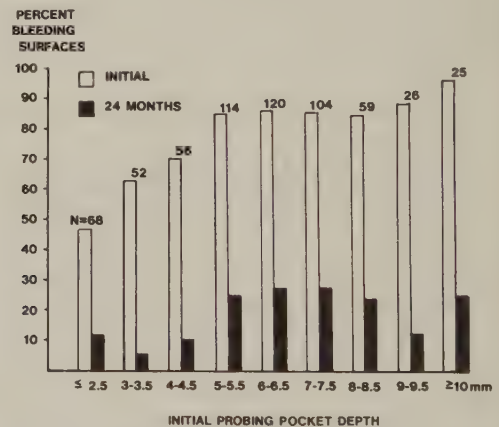


Fig. 10. Proportions (%) of surfaces showing bleeding upon probing at initial examination and at 24 months grouped by initial probing pocket depth. Pooled data from all patients. N=number of available surfaces.

Nach 24 Monaten – prozentualer Anteil der Oberflächen, die beim Sondieren während der Ausgangsuntersuchung bluteten. Zusammengefasste Daten aller Patienten. N=Anzahl der zur Verfügung stehenden Oberflächen.

Pourcentages de surfaces avec saignement au sondage lors de l'examen initial et après 24 mois, groupés par profondeur initiale de poche. Données groupées pour tous les patients. N=nombre de surfaces disponibles.

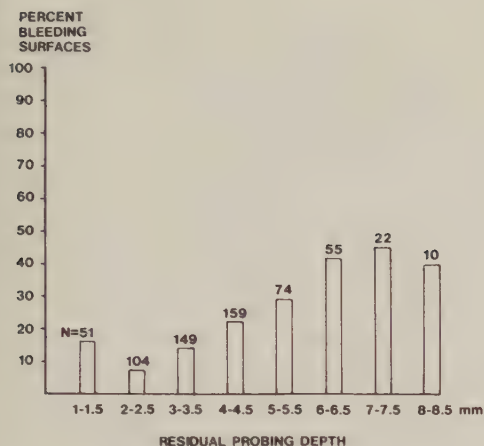


Fig. 11. Proportions (%) of surfaces showing bleeding upon probing at the 24-month examination grouped by residual probing depth at 24 months. Pooled data from all patients. N=number of available surfaces.

Prozentualer Anteil der Oberflächen, die bei der 2-Jahresuntersuchung bluteten – gruppiert nach der residualen Taschentiefe nach 24 Monaten. Zusammengefasste Daten aller Patienten. N=Anzahl zur Verfügung stehender Oberflächen.

Pourcentages de surfaces avec saignement au sondage lors de l'examen après 24 mois, groupés par profondeur résiduelle de poche après 24 mois. Données groupées de tous les patients. N=nombre de surfaces disponibles.

Relationship of bleeding on probing and probing pocket depth

The proportion of bleeding surfaces at the initial examination was 85% or more for surfaces with initial probing pocket depth ≥ 5.0 mm (Fig. 10). At the 24-month examination the bleeding frequencies were markedly reduced

not only for shallow pockets, but also for pockets of deep initial probing depth.

The bleeding frequencies at the 24-month examination according to residual probing depth are shown in Fig. 11. Bleeding upon probing was encountered more often in pockets with deeper residual probing depths than in shallow depths.

Time of instrumentation

Mean time of instrumentation per tooth is presented in Table 4.

Discussion

In a previous study the effect of nonsurgical periodontal therapy was investigated in patients with severely advanced periodontitis (Badersten et al. 1983a). Incisors, cuspids and premolars with periodontal pockets 4–12 mm deep were treated by plaque control and supra- and subgingival debridement, using hand and ultrasonic instruments. The results demonstrated that substantial improvement of periodontal conditions can be accomplished following nonsurgical treatment of severely advanced periodontitis.

A comparison of the patients and the results of the previous study with our present study discloses striking similarities. The mean initial probing pocket depths and bleeding scores are comparable, 5.5–5.9 mm and 80–90%, respectively. Also, the response to the nonsurgical therapy was uniform. The mean pocket depth

Table 4. Mean time of instrumentation (min per tooth)

Mittlerer Zeitverbrauch bei der instrumentalen Behandlung (in Minuten pro Zahn)

Durée moyenne d'instrumentation (en minutes par dent)

	1 instrumentation	3 instrumentations
Instrumentation No. 1 (at 0 months)	4.9	4.7
Instrumentation No. 2 (at 3 months)	–	2.5
Instrumentation No. 3 (at 6 months)	–	0.7
Total	4.9	7.9

was reduced to 3.5–3.9 mm. Bleeding scores were reduced to 15–20% in both patient groups. The mean gain of probing attachment level was similar. The pattern of healing for surfaces of varying initial probing pocket depth corresponded closely. In both studies the full effect of treatment was not obtained until 6–9 months after start of instrumentation.

Our previous study did not demonstrate any differences in results of therapy following instrumentation with hand instruments compared to ultrasonics. The results obtained by the 2 participating operators were also similar. Accordingly, only 1 of the operators and 1 method of instrumentation (ultrasonics) was selected for the present study investigating the effect of single versus repeated instrumentation. The results showed that a similar healing response was accomplished by a single initial instrumentation as by 3 instrumentations, each separated by 3 months. This indicates that the operator in question accomplished an adequate debridement during the initial instrumentation and – if a number of surfaces was not adequately instrumented initially – repeated instrumentation of such sites was of limited value.

Healing following nonsurgical periodontal therapy is a gradual process over several months involving gingival recession and improved adaptation of the gingival tissues. It is conceivable that subgingival recolonization by microorganisms may easily occur during this phase before sufficient gingival healing has taken place. Thus, repeated instrumentation during this period would facilitate continuous improvement and prevent recurrence of disease. However, the lack of differences in results between a single and repeated instrumentation seems to suggest that recolonization during the healing phase is not a major clinical problem.

Following instrumentation, only plaque control and tooth polishing was carried out during the remaining period of observation. This means that during intervals of 18 and 24 months, respectively, for the 2 sides of the jaws there was no subgingival instrumentation. The means of

the clinical parameters remained unchanged during these intervals and did not demonstrate any indications of recurrence of disease. This included sites with initial probing pocket depth ≥ 7 mm. This fact further seems to suggest that subgingival recolonization by microorganisms is no major clinical problem.

The participating patients maintained a high standard of supragingival plaque control throughout the study. Most likely, this provides the explanation for the lack of recurrence of disease. Mousques et al. (1980) have demonstrated that subgingival recolonization may occur within a few months following instrumentation in patients with unimproved plaque control.

The limitations of the present study should be carefully considered. Molars were excluded from observation. Recolonization by microorganisms may occur more readily in these teeth, especially in areas with furcation involvement. Also, the fact that no differences were observed between the means of the parameters of healing does not exclude the possibility that repeated instrumentation could have been advantageous for occasional surfaces.

If repeated instrumentation can be obviated, a significant reduction in time of active therapy will be accomplished. Since only 1 operator was used in the present study and since the results obtained are valid for this operator only, a single episode of instrumentation can not be recommended for general clinical use. Each individual therapist needs to find out if he or she can reduce the number of instrumentations, e.g. by treating a number of patients with a split mouth approach similar to that employed in the present study.

Acknowledgements

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Zusammenfassung

Der Effekt nicht-chirurgischer Parodontaltherapie

III. Einmalige gegenüber wiederholter Instrumentalbehandlung

Das Studium der Heilungsvorgänge nach nicht-chirurgischer Parodontaltherapie wurde durch den Vergleich der therapeutischen Effekte zwischen einmaliger und in 3-monatlichen Abständen vorgenommener, dreimaliger Instrumentalbehandlung erweitert. Bei 13 Patienten mit parodontalen Taschen bis zu 11 mm wurden Schneidezähne, Eckzähne und Prämolaren mittels Plaquekontrolle, sowie mit supra- und subgingivaler Zahnsteinbehandlung mit Ultraschallinstrumenten behandelt. Zum Vergleich des Effektes der beiden Behandlungssequenzen wurde ein "split mouth"-Versuchsansatz angewendet. Die Behandlungsergebnisse wurden durch das Registrieren der Plaque-Scores (Beurteilungseinheiten), der Blutungstendenz nach dem Sondieren, sowie durch das Sondieren der Taschentiefen und des Attachmentniveaus ausgewertet. Während der ersten 9 Monate nach der Einleitung der Therapie kam es zu schrittweiser, markanter Verbesserung des parodontalen Status. Während der dann noch verbleibenden 15 Monate der 24-monatlichen Versuchsperiode wurden keine weiteren Veränderungen der registrierten Parameter beobachtet. Beim Vergleich zwischen den therapeutischen Effekten der einmaligen und der wiederholten Instrumentalbehandlung wurden keine Unterschiede gesehen. Tiefe Taschen bei Inzisiven, Eckzähnen und Prämolaren scheinen also mit Erfolg durch Plaquekontrolle und einmalige Instrumentalbehandlung behandelt werden zu können. Die vorliegenden Resultate sagen weiterhin aus, dass ein, während der Heilungsperiode durch Rekolonisation der Mikroorganismen hervorgerufenen, Krankheitsrezidiv kein bedeutenderes klinisches Problem darstellt.

Résumé

Effet du traitement parodontal non-chirurgical

III. Instrumentation unique comparée à une instrumentation triple

Les suites d'un traitement parodontal non chirurgical ont été observées chez 13 patients dont les poches parodontales atteignaient jusqu'à 11 mm. Des incisives, canines et prémolaires ont été traitées par contrôle de plaque dentaire et détartrage sus- et sous-

gingival aux ultrasons (1 fois pour la moitié des dents et 3 fois, soit 1 fois par trimestre, pour l'autre moitié). Les résultats ont été évalués en enregistrant les scores de plaque, le saignement au sondage, les profondeurs de poche et les niveaux d'attache. Durant les 9 premiers mois de l'expérience, une nette amélioration progressive de l'état du parodonte est apparue. Durant les 15 derniers mois de cette expérience de 2 ans, aucun changement supplémentaire n'a été enregistré. Aucune différence n'a été observée entre les résultats obtenus avec une instrumentation unique et une triple instrumentation. Les poches parodontales profondes des incisives, canines et prémolaires peuvent donc être traitées avec succès grâce à un contrôle de plaque et un épisode d'instrumentation. Les résultats suggèrent également que la réapparition de la maladie par recolonisation bactérienne sousgingivale durant la guérison ne peut constituer un problème clinique majeur.

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Paper III

EFFECT OF NONSURGICAL PERIODONTAL THERAPY

IV. OPERATOR VARIABILITY

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Key words: Probing attachment loss - clinical
measurements - nonsurgical - periodontal treatment

Running head: Nonsurgical periodontal therapy

ABSTRACT

Healing following nonsurgical periodontal therapy was studied and the results of instrumentation performed by 6 operators compared. Incisors, cuspids and premolars with periodontal pockets up to 11 mm deep in 20 patients were treated by plaque control and a single episode of supra- and subgingival debridement. A split mouth approach was used to compare the participating therapists. The effects of the therapy were monitored using changes in plaque score, bleeding score, probing pocket depth and probing attachment level.

Marked improvement, similar to that seen in previous studies evaluating nonsurgical therapy was noted during the initial 6-9 months. No further changes of the recorded parameters could be observed during the rest of the 24-month observation period. Differences between sites treated by the various operators were negligible. Thus, it appears, that deep periodontal pockets in incisors, cuspids and premolars may be successfully treated by plaque control and 1 episode of instrumentation and that operator variability may be limited.

INTRODUCTION

In 2 previous studies we investigated the effect of nonsurgical periodontal therapy in patients with moderate and severe periodontitis (Badersten et al. 1981, 1984a). These studies provided information on healing following the combined therapy of oral hygiene instruction and supra- and subgingival debridement. The results suggested that nonsurgical periodontal therapy is effective in treating pockets up to 12 mm deep. Results did not differ between hand and ultrasonic instrumentation or between 2 participating operators.

In the above studies, periodontal pockets were debrided 3 times, once every 2 to 4 months. Badersten et al. (1984b) investigated the necessity of such repeated instrumentation and found that the effects of a single initial instrumentation did not differ from the effects of 3 instrumentations. Thus, deep periodontal pockets in the teeth under study - incisors, cuspids and bicuspid - may be successfully treated by oral hygiene instruction and a single episode of instrumentation.

The success of our previous studies may be related to the skill of the 2 participating operators; if so, our conclusions are valid for these operators only. The present study was designed to compare the results achieved by other operators in treating severe periodontitis with a single instrumentation.

MATERIAL AND METHODS

20 patients, 16 males and 4 females, 28 to 64 years of age, with severe periodontal disease were selected for the study. The incisors, cuspids and premolars in either the maxilla or the mandible were studied. Each patient contributed from 6 to 10 teeth for study. The dentitions of these patients displayed generalized periodontal destruction involving right and left sides of the mouth to a similar extent. Periodontal pockets at least 5.0 mm deep with calculus and bleeding on probing were present on 2 or more aspects of each tooth. The therapy and methods of the present investigation were similar to those of Badersten et al. (1984b).

Oral hygiene instruction

Patients were instructed in oral hygiene on 2 or 3 separate occasions during the first month of the study. Additional instruction and reinforcement was

provided and teeth polished according to individual needs throughout the 24 months duration of the study.

Debridement of periodontal pockets

The periodontal pockets were debrided by a periodontist (author R.N., operator 2 in Badersten et al. 1981, 1984a) or by 1 of a group of 5 dental hygienists. The hygienists were all employed in Departments of Periodontology in the Public Dental Services in Lund and Kristianstad, Sweden. Their professional experience varied between 3 and 14 years. This study does not involve operator 1 from our previous studies but compares operator 2 with a new group of operators designated as operators 3 to 7.

The periodontal pockets were debrided immediately following the initial examination. A split-mouth design was used: operator 2 was assigned at random to debride the sites in 1 side of the jaw studied; 1 of the other operators was assigned to debride the sites in the other half. Operators 3 to 7 treated 2 to 5 patients each. All debridement was performed under local anesthesia. Hand and/or ultrasonic instruments were used according to individual operator preference. The average time per tooth required for each operator was recorded.

Methods of measurement

Measurements of dental plaque, bleeding on probing, probing pocket depth and probing attachment level were recorded at the initial examination and at every 3rd month by an examiner (author A.B.), who was unaware of which operator had treated which teeth. Recordings were made at 6 aspects of each tooth: mesio-buccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual.

Probing pocket and probing attachment measurements were recorded after the plaque and bleeding scores. Bleeding on probing, probing pocket depths and probing attachment levels were determined with an electronic, pressure sensitive probe (Electronic Periodontal Probe, Model 200, Vine Valley Research, Middlesex, NY, USA) with a specially machined tip, 0.5 mm in diameter and calibrated in 1-mm increments. Probing pocket and probing attachment measurements were taken to the nearest 0.5 mm and the probing force was standardized to 0.75 N. The margins of soft acrylic onlays provided reference points for the attachment level measurements.

RESULTS

Table 1 shows the number and distribution of sites by subgroup of patients and by operator. In all, 1056 sites were treated, half of which were treated by operator 2. The number of sites treated by each of the other operators ranged from 60 to 138.

Table 2 shows the distribution of initial probing pocket depths among the sites treated by the different operators. A limited number of sites ≥ 7.0 mm deep were treated by some of the operators.

Table 3 shows the average time taken by each operator to debride each tooth. A range of 9 to 12 minutes per tooth was found in the group of operators.

Table 1. Number and distribution of treated sites by subgroup of patients and by operator

Patient subgroup	Operator					
	2	3	4	5	6	7
1 through 5	138	138				
6 through 9	84		84			
10 through 14	138			138		
15 through 16	60				60	
17 through 20	108					108
Total	528	138	84	138	60	108

Table 2. Number and distribution of sites by initial probing pocket depth and by operator

Initial probing pocket depth (mm)	Operator					
	2	3	4	5	6	7
≤ 3.5	134	28	27	36	11	22
4.0 - 6.5	252	75	37	64	40	57
≥ 7.0	142	35	20	38	9	29
Total	528	138	84	138	60	108

Table 3. Mean time of debridement per tooth by operator

Operator	Debridement time per tooth (min)
2	9.1
3	10.4
4	12.2
5	9.4
6	9.6
7	8.7

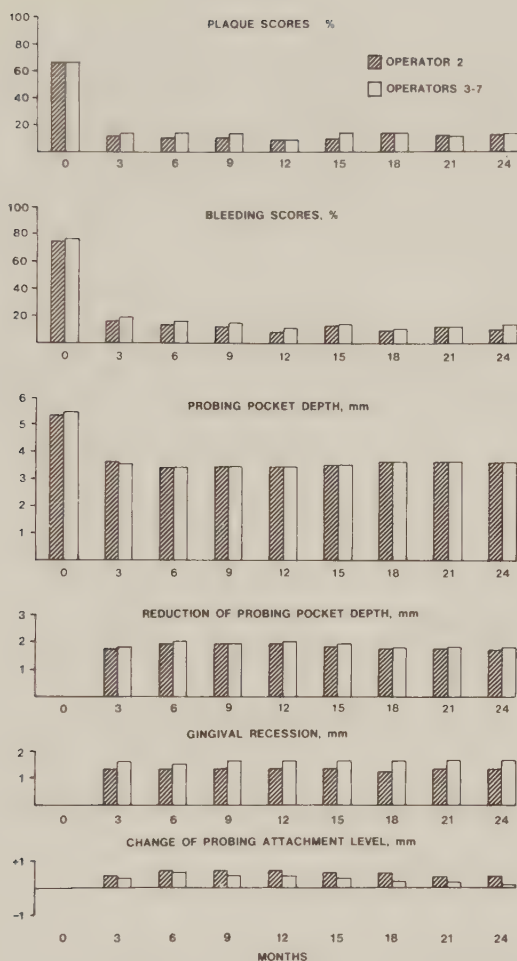


Fig. 1. Means of the clinical measurements from sites treated by operator 2 compared to the means from sites treated by all other operators throughout the 24 months of study.

Dental plaque

At 3 months, the average plaque score had dropped from an initial mean of 66% to approximately 10%. Changes after 3 months were minimal. The reduction in plaque scores for sites treated by operator 2 was similar to the mean reduction achieved for sites treated by operators 3 to 7 (Fig. 1).

Bleeding on probing

Bleeding scores dropped from an initial mean of approximately 75% to around 17% at 3 months and to around 10% at 12 months. Further changes were minimal. There was no difference in bleeding scores at sites treated by operator 2 in comparison with mean scores for sites treated by operators 3 to 7 (Fig. 1).

Probing pocket depth

Probing pocket depths decreased from an initial average of 5.4 mm to around 3.5 mm at 3 months and remained at this depth during the remainder of the study. Probing pocket depth reduction for sites debrided by operator 2 was similar to that of the mean for sites treated by the other operators (Fig. 1).

Gingival recession

Most of the gingival recession occurred during the first 3 months. Somewhat more gingival recession was seen for those sites treated by operators 3 to 7 collectively (mean 1.6 mm) than for those treated by operator 2 (mean 1.3 mm) (Fig. 1).

Probing attachment level

Probing attachment levels showed gains of 0.1 - 0.6 mm throughout the study. Slightly more gain occurred for sites treated by operator 2 than for sites treated by operators 3 to 7 collectively (Fig. 1).

Changes related to initial probing pocket depth

Fig. 2 outlines residual probing pocket depths, attachment level changes and gingival recession at 24 months from all sites in relation to initial probing pocket depth. Operator 2 is compared to the collective values for operators 3 to 7. Initially deeper pockets had more gingival recession, more gain of probing attachment and deeper residual probing depth than initially shallower sites. Sites with probing depths initially 4.5 mm or less lost from 0.2 to 1.0 mm in probing attachment, while pockets initially 8.0 mm or more in

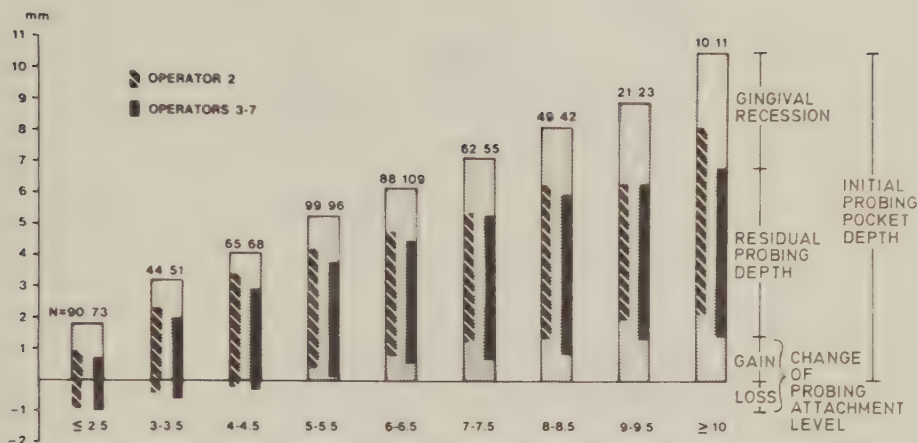


Fig. 2. Average values for gingival recession, residual probing depth and gain/loss of probing attachment at 24 months related to initial probing pocket depth. Means for operator 2 are compared to the collective means for operators 3 to 7. N = number of available surfaces.

depths gained an average of 0.9 to 2.2 mm. Sites treated by operator 2 showed slightly less recession and slightly more gain in probing attachment than sites treated by operators 3 to 7.

Changes in pockets initially ≥ 7.0 mm deep

Figs. 3 to 6 compare changes in bleeding score, probing pocket depth, gingival recession and probing attachment level for sites treated by operator 2 to sites treated by each of the other operators.

Bleeding scores dropped from about 90% to approximately 20% after 3 months. Operators 3, 4 and 5 showed a trend towards higher bleeding scores than operator 2 (Fig. 3).

Probing pocket depths decreased from an average of 8.0 mm to between 4.0 and 5.0 mm after 3 to 6 months. No further change was noted and no differences were found between sites treated by different operators (Fig. 4).

Gingival recession amounted to 1.5 to 2.5 mm. Operators 3, 4, 6 and 7 obtained slightly more recession than operator 2 (Fig. 5).

Attachment levels increased by 1.0 to 2.0 mm. Operators 3, 4, 6 and 7 obtained somewhat less gain of probing attachment as compared to operator 2 (Fig. 6).

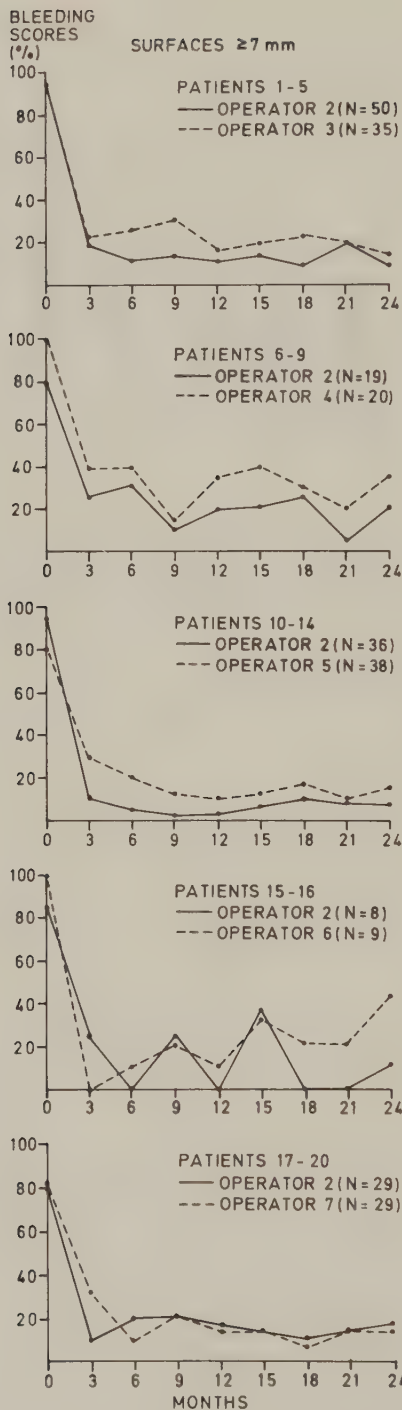


Fig. 3. Bleeding scores at sites with initial probing pocket depth ≥ 7 mm for operator 2 compared to each of the other operators. N = number of available surfaces.

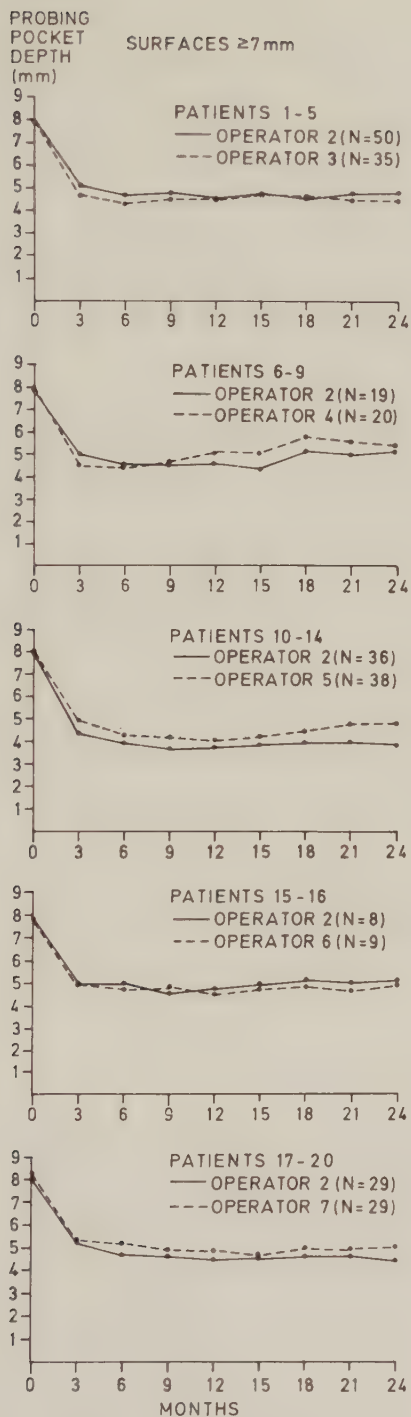


Fig. 4. Changes in probing pocket depth at sites with initial probing pocket depth ≥ 7 mm for operator 2 compared to each of the other operators. N = number of available surfaces.

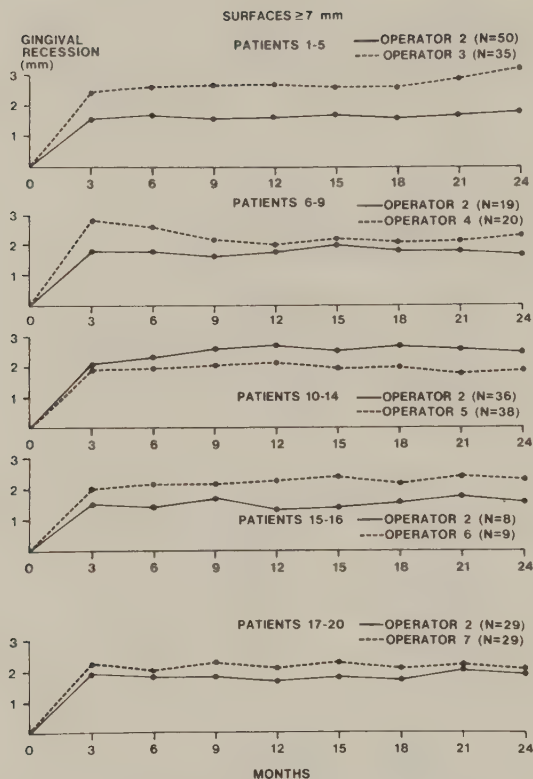


Fig. 5. Gingival recession at sites with initial probing pocket depth ≥ 7 mm for operator 2 compared to each of the other operators. N = number of available surfaces.

Results of statistical analyses

Gingival recession and change of probing attachment level at 24 months for operator 2 compared to each of operators 3 to 7 were statistically evaluated using chi square tests for subgroup of sites with different initial probing pocket depths. Operator 3 demonstrated significantly more gingival recession for sites ≤ 3.5 mm and for sites 4.0 - 6.5 mm than operator 2 (Table 4). Operator 3 also showed significantly less improvement of probing attachment levels for sites 4.0 - 6.5 mm and for sites ≥ 7.0 mm than operator 2 (Table 5). Operator 4 demonstrated significantly more gingival recession for sites 4.0 - 6.5 mm than operator 2. Operator 5, 6 and 7 did not show any significant differences compared to operator 2 for any subgroup of pockets.

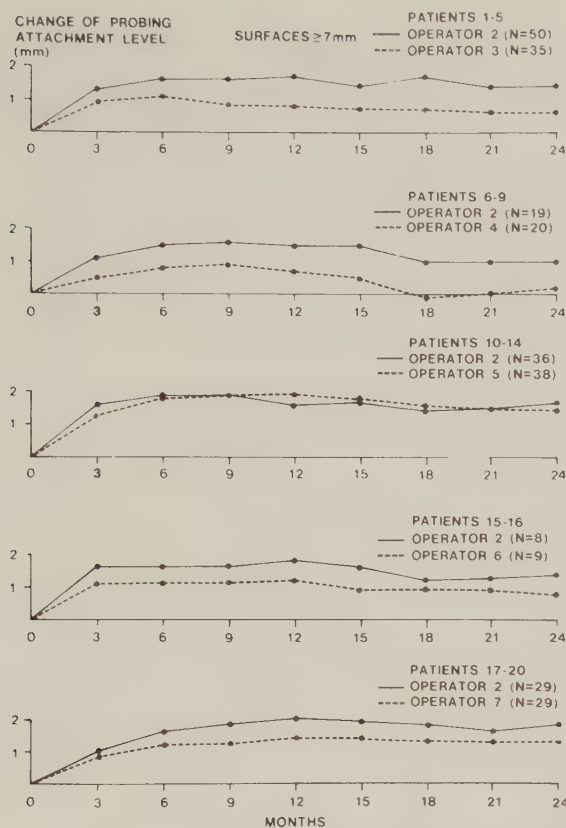


Fig. 6. Changes in probing attachment level at sites with initial probing pocket depth ≥ 7 mm for operator 2 compared to each of the other operators. N = number of available surfaces.

DISCUSSION

Our previous studies investigated the effect of nonsurgical periodontal therapy in patients with moderate to severe periodontitis (Badersten et al. 1981, 1984a,b). Incisors, cuspids and premolars with periodontal pockets 4 to 12 mm deep were treated by plaque control and supra- and subgingival debridement. The findings demonstrated that this treatment resulted in marked clinical improvement. Probing pocket depths decreased irrespective of initial depth. More gingival recession and probing attachment gain was observed for deeper sites than for shallower sites. Sites with initial shallow probing depths demonstrated some loss of attachment. The results of our present study are comparable with those of our previous studies.

Table 4. Gingival recession at 24 months. Results of chi square tests comparing operator 2 to each of operators 3 through 7 for sites with different initial probing pocket depths. 2 x 2 tables with gingival recession ≥ 1.5 mm and ≤ 1.0 mm. Number of available sites for operators 3 through 7 as presented in Table 2

Operators compared	Initial probing pocket depth (mm)		
	≤ 3.5	4.0 - 6.5	≥ 7.0
2 to 3	$\chi^2=6.6$ $p<0.02$	$\chi^2=7.7$ $p<0.01$	$\chi^2=3.0$ N.S.
2 to 4	$\chi^2=0.1$ N.S.	$\chi^2=8.4$ $p<0.01$	$\chi^2=3.0$ N.S.
2 to 5	$\chi^2=0.8$ N.S.	$\chi^2=3.8$ N.S.	$\chi^2=0.5$ N.S.
2 to 6	$\chi^2=1.2$ N.S.	$\chi^2=0.7$ N.S.	$p=0.24^*)$
2 to 7	$\chi^2=2.8$ N.S.	$\chi^2=2.9$ N.S.	$\chi^2=0.1$ N.S.

*) Fisher's exact test

In our previous studies, results did not differ between hand and ultrasonic instrumentation or between single and repeated instrumentation. Furthermore, similar results were obtained by 2 different operators. The present investigation also indicates similar healing following treatment by different operators; only small differences between operators were observed. Sites treated by operators 3 to 7 as a group demonstrated slightly more gingival recession and less gain of probing attachment than sites treated by operator 2. In pockets ≥ 7.0 mm similar reductions in bleeding score and pocket depth were demonstrated. Differences in gingival recession and gain of probing attachment, although present, were small.

The average time spent instrumenting a single tooth ranged from 9 to 12 minutes. This limited variation in time used by these operators is of interest and may indicate that an average of 10 minutes per non-molar tooth is required for adequate treatment of advanced periodontitis. However, similar clinical results were obtained in 1 of our previous studies in which another operator (operator 1) used an average of 5 minutes per tooth in the treatment of similarly advanced patients (Badersten et al. 1984b).

Table 5. Change of probing attachment at 24 months. Results of chi square tests comparing operator 2 to each of operators 3 through 7 for sites with different initial probing pocket depths. 2 x 3 tables with attachment changes: ≤ -1.5 mm; $-1.0 - +1.0$ mm; $\geq +1.5$ mm. Number of available sites for operators 3 through 7 as presented in Table 2.

Operators compared	Initial probing pocket depth (mm)		
	≤ 3.5	4.0 - 6.5	≥ 7.0
2 to 3	$\chi^2=2.4$ N.S.	$\chi^2=6.6$ $p < 0.05$	$\chi^2=8.1$ $p < 0.02$
2 to 4	$\chi^2=0.1$ N.S.	$\chi^2=3.4$ N.S.	$\chi^2=3.6$ N.S.
2 to 5	$\chi^2=0.0$ N.S.	$\chi^2=5.2$ N.S.	$\chi^2=3.3$ N.S.
2 to 6	$\chi^2=0.2$ N.S.	$\chi^2=3.0$ N.S.	$p=0.44^*)$
2 to 7	$\chi^2=0.0$ N.S.	$\chi^2=5.8$ N.S.	$\chi^2=3.2$ N.S.

*) Fisher's exact test

Further evidence that nonsurgical periodontal therapy is successful in the treatment of periodontitis can be found in a number of recent studies (Hill et al. 1981, Isidor 1981, Lindhe et al. 1982a, b, Pihlstrom et al. 1983). In spite of the fact that the treatment employed in these investigations has been performed in different clinics and by different operators, the results are comparable. Therefore, it seems that in the circumstances appertaining to a clinical research environment, the effect of operator variability on the results of nonsurgical periodontal therapy is minimal.

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Paper IV

EFFECT OF NONSURGICAL PERIODONTAL THERAPY

V. PATTERNS OF PROBING ATTACHMENT
LOSS IN NON-RESPONDING SITES

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Key words: Probing attachment loss - clinical
measurements - nonsurgical - periodontal treatment

Running head: Nonsurgical periodontal therapy

ABSTRACT

Incisors, cuspids and premolars in 33 patients with advanced chronic periodontitis were treated by plaque control and 1 single episode of supra- and subgingival debridement. The results were monitored by probing attachment level measurements for 6 sites of each tooth every 3rd month during 24 months. A total of 1368 sites were observed. From these were selected 280 "non-responding" sites showing 1.0 mm or more loss of probing attachment at 24 months compared to baseline. Scatter diagrams of the sequence of 9 probing attachment recordings obtained during the 24-month study were produced for each of these 280 sites. Study of these scatter diagrams resulted in identification of 7 different patterns of probing attachment change over time. A linear pattern of gradual loss of probing attachment throughout the 24-month observation period was found for 73% of the non-responding sites. Of the less frequently seen patterns 3 approximated a linear course and 3 were non-linear. Linear analysis of regression as a statistical method to determine attachment loss for individual sites seems to be suitable for sites with linear patterns and for sites approximating a linear pattern. The insensitivity of regression analysis in non-linear patterns may be acceptable if a cautious analysis is warranted.

INTRODUCTION

Periodontal therapy is usually initiated by oral hygiene instruction and supra- and subgingival debridement. On the average, this therapy results in a slight deterioration of probing attachment levels in sites with shallow probing depth, whilst deep periodontal pockets demonstrate gain of probing attachment (Badersten et al. 1981, 1984a, b, c, Hill et al. 1981, Isidor 1981, Lindhe et al. 1982a, b, Pihlstrom et al. 1983). In spite of the fact that the majority of deep pockets respond with gain of probing attachment some individual sites seem to demonstrate a loss (Badersten 1981, 1984a, b, c). Appropriate identification of such sites with probing attachment loss is important in order to determine the limitations of the initial treatment procedures and to assess the need for supplementary procedures. This study: 1) describes patterns of probing attachment loss observed amongst non-responding sites following initial therapy; 2) reports the incidence of these patterns in sites of different probing depths; and 3) evaluates linear regression analysis for determination of attachment loss in sites with various attachment loss patterns.

MATERIAL AND METHODS

The material for the present report originates from 2 previous studies on nonsurgical periodontal therapy (Badersten et al. 1984b, c). A total of 33 patients, 23 males and 10 females, 28 to 64 years of age, were available. The incisors, cuspids and premolars in either the maxilla or the mandible were studied. Each patient contributed from 6 to 10 teeth for study. The investigated parts of the dentitions of these patients displayed generalized periodontal destruction involving right and left sides of the mouth to a similar extent. Periodontal pockets at least 5.0 mm deep with calculus and bleeding on probing were present on 2 or more aspects of each tooth.

Therapy

Following the baseline measurements, the patients were subjected to 2-3 visits for oral hygiene instruction. Additional instruction and reinforcement was given and teeth polished according to individual needs throughout the 24-month duration of the study. A single episode of supra- and subgingival debridement was performed immediately following the initial examination. No additional subgingival instrumentation was performed.

Methods of measurement

Measurements of probing attachment level were taken at the baseline examination and at every 3rd month by one examiner (author A.B.). Recordings were made at 6 aspects of each tooth: mesio Buccal, mid Buccal, disto Buccal, mesio Lingual, mid Lingual and disto Lingual. The measurements were taken to the nearest 0.5 mm. A probe tip, 0.5 mm in diameter and calibrated in 1-mm increments, was used. The margins of soft acrylic onlays provided reference points for the attachment level measurements. A pressure sensitive probe with the probing force standardized to 0.75 N was used.

Analysis of non-responding sites

A total of 1368 sites were studied (312 sites from Badersten et al. 1984b and 1056 sites from Badersten et al. 1984c). From these were selected 280 "non-responding" sites defined as surfaces showing 1.0 mm or more loss of probing attachment at 24 months compared to baseline. Scatter diagrams of the sequence of 9 probing attachment recordings obtained during the 24-month study were produced for each of these 280 sites (see examples in Figs. 2-8). The scatter diagrams were first surveyed jointly by 2 investigators (authors A.B. and J.E.) who agreed that 7 different patterns of probing attachment level change over time could be identified (patterns A through G). Subsequently, the diagrams were studied independently by the 2 investigators and the pattern for each of the 280 sites was determined by each investigator. Classification of the sites was achieved by acceptance of concordant findings and by mutual agreement on those sites for which the 2 investigators had initially designated different patterns.

RESULTS

The 7 patterns of probing attachment change recognized amongst the 280 non-responding sites are presented in Fig. 1. Examples of sites with these various patterns are shown in Figs. 2-8. Examples have been chosen to demonstrate the variations observed within each pattern and to illustrate that, to some extent, the classification was an arbitrary and subjective procedure.

A gradual loss of probing attachment throughout the 24-month observation period (Pattern A) was found for 73% of the non-responding sites (Table 1). A loss of probing attachment between the 0- and 3-month recordings followed by stable measurements throughout the remaining observation period (Pattern E) was observed for 12% of the sites. A gradual loss of probing attachment

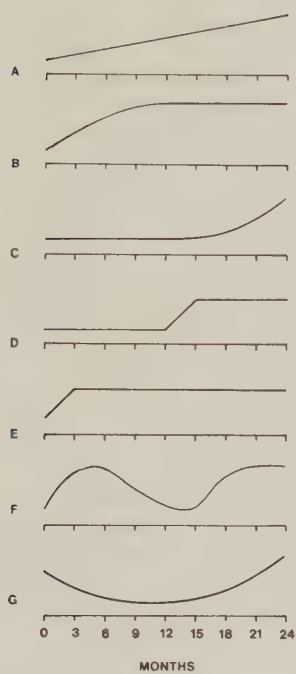


Fig. 1. Patterns of probing attachment level change recognized amongst the 280 non-responding sites:

Pattern A: a gradual loss of probing attachment throughout the period of observation.

Pattern B: a gradual loss during an early portion of the observation period followed by stabilization.

Pattern C: stable measurements during an early portion of the observation period followed by a gradual loss at the end.

Pattern D: stable measurements initially followed by a loss between 2 recording intervals followed by stabilized measurements during a final portion of the observation period.

Pattern E: a loss between the 0- and 3-month recordings followed by stable measurements throughout the remaining observation period.

Pattern F: undulating changes.

Pattern G: an u-shaped change with initial gain followed by loss.

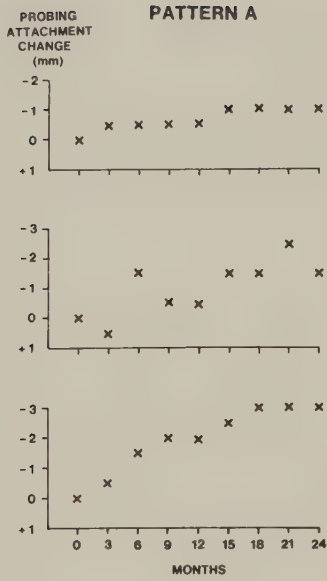


Fig. 2. Examples of sites with loss of probing attachment corresponding to Pattern A.

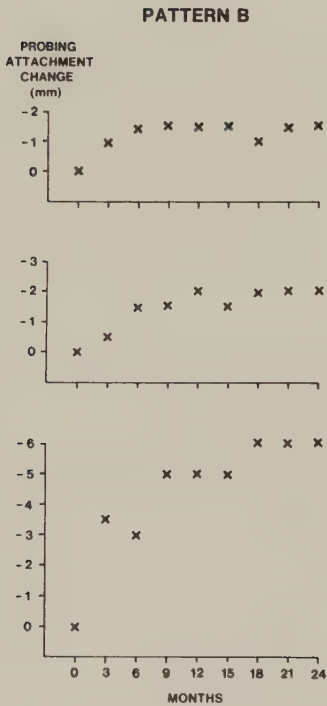


Fig. 3. Examples of sites with loss of probing attachment corresponding to Pattern B.

Fig. 4. Examples of sites with loss of probing attachment corresponding to Pattern C.

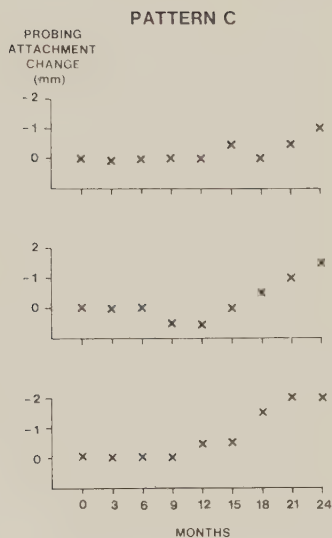
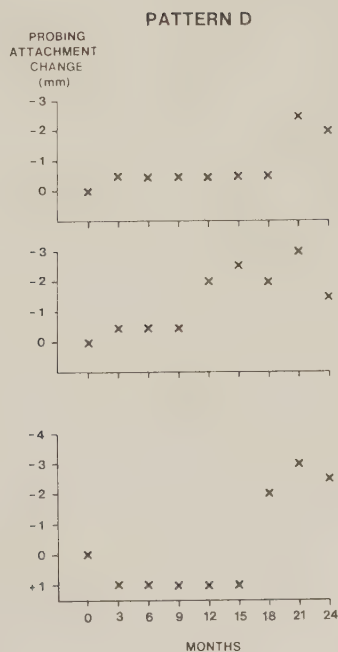


Fig. 5. Examples of sites with loss of probing attachment corresponding to Pattern D.



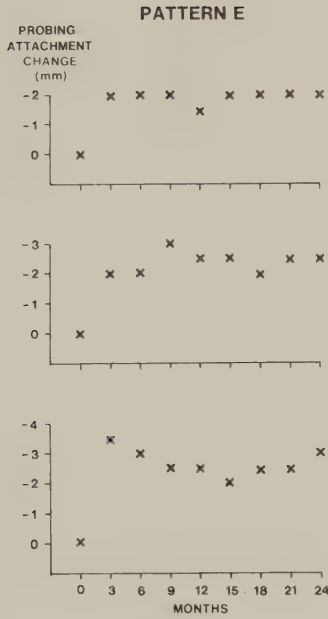


Fig. 6. Examples of sites with loss of probing attachment corresponding to Pattern E.

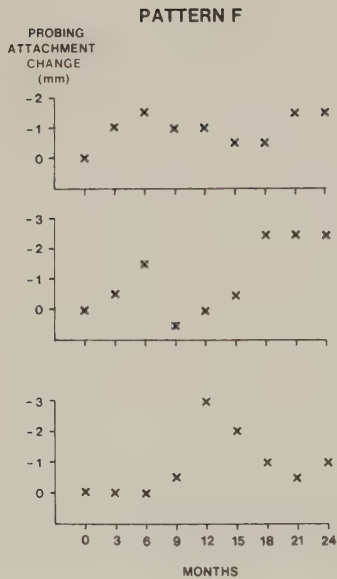


Fig. 7. Examples of sites with loss of probing attachment corresponding to Pattern F.

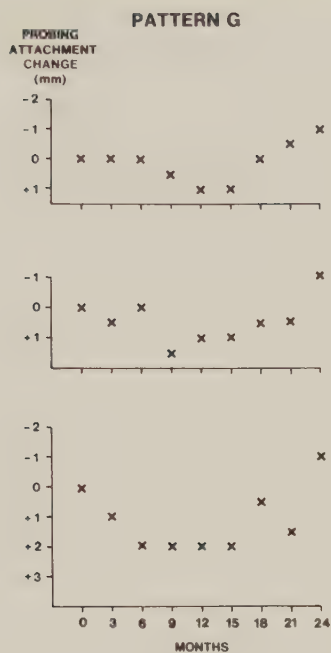


Fig. 8. Examples of sites with loss of probing attachment corresponding to Pattern G.

Table 1. Percentage of non-responding sites by pattern of probing attachment loss and initial probing pocket depth

Initial probing pocket depth (mm)	Pattern						
	A	B	C	D	E	F	G
≤ 3.5 (N=147)	72	8	1	1	16	1	0
4.0 - 6.5 (N=101)	81	1	2	4	9	1	2
≥ 7.0 (N=32)	53	3	13	9	3	9	9
Mean (N=280)	73	5	3	3	12	2	2

during an early portion of the observation period followed by stabilized measurements (Pattern B) was found for 5% of the sites. Other patterns were less frequent.

Sites with an initial probing pocket depth ≤ 3.5 mm demonstrated a higher frequency of Pattern B and Pattern E than sites with deeper initial pocket depth. Sites with initial probing pocket depth ≥ 7.0 mm showed a lower incidence of linear change (Pattern A) and more variation of pattern than shallower sites (Table 1).

DISCUSSION

Goodson et al. (1982) studied changes in probing attachment levels over periods of up to 23 months in patients with untreated periodontitis and observed sites that became progressively deeper during the monitoring period together with sites that showed a pattern of early probing attachment loss and subsequent probing attachment gain. Also, sites that were initially stable but showed probing attachment loss at the end of the monitoring period were observed. In the present study of patients monitored following initial periodontal therapy, patterns of probing attachment change similar to those described by Goodson et al. (1982) were observed.

The interpretation of probing attachment level measurements is complicated by the inability of probing to accurately disclose the connective tissue attachment level and also by the limited reproducibility of the probing measurements.

Before therapy, in the presence of inflammation, the probe tip generally penetrates beyond the apical termination of the junctional epithelium and into the subjacent connective tissue (Listgarten 1980, Caton et al. 1981, Jansen et al. 1981, van der Velden & Jansen 1981, Fowler et al. 1982, van der Velden 1982). Therefore, it seems reasonable to assume that a more apical position of the probe tip after therapy compared to the pretherapy level is associated with loss of connective tissue attachment. Improved probing attachment levels after therapy, on the other hand, do not seem to be associated with a corresponding gain of connective tissue attachment, but with improved tissue tonus and better adaptation of the junctional epithelium to the tooth (Fowler et al. 1982). Thus, analysis of the response of individual sites, focusing on probing attachment loss, may indicate a true underlying deterioration in connective tissue support.

Cercek et al. (1983) and Badersten et al (1984d) found that on the average, 90% of probing attachment level measurements could be reproduced within a ± 1.0 mm deviation. However, it has been found that the level of reproducibility may vary considerably by patient, by tooth type, by tooth surface location and by pocket depth of the examined site and differs for the same site before and after therapy (Glavind & Löe 1967, Löe et al. 1978, van der Velden & de Vries 1980, Goodson et al. 1982, Haffajee et al. 1983, Badersten et al. 1984d). Therefore, interpretation of changes of probing attachment level for individual sites should be based upon the reproducibility level for each individual site, not on average reproducibility data for the whole dentition. A number of repeated measurements from each site obtained both before and after therapy would allow calculation of individual site reproducibility. However, from a practical point of view it may be difficult to expose the investigated subjects to sufficient number of repeated probings to obtain reliable reproducibility data. The approach taken in the present study - measurements every 3rd month during 24 months - may be an operational compromise. Changes in probing attachment levels over time can be evaluated in conjunction with the variability of the longitudinal recordings.

The selection of method for analysis of longitudinal series of probing attachment measurements becomes critical. The magnitude of change as well as the pattern of recorded change need to be considered. In the present study it was observed that 73% of the non-responding sites showed a gradual, linear deterioration of the probing attachment levels. This finding corresponds to previous observations that periodontal disease, on the average, progresses gradually over time (Löe et al. 1978, Axelsson & Lindhe 1981). Utilization of analysis of regression, as suggested by Goodson et al. (1982), should be suitable to evaluate probing attachment loss in these sites. Calculation of the slope of the regression line will determine the rate of loss over time. Determination of the probability level for individual slopes will consider the variability of the individual data points about the regression line, i.e. will include consideration of the level of reproducibility of the measurements at the specific site.

Fig. 9 presents examples of sites with linear attachment loss (Pattern A) and the results of analyses of regression. The examples have been selected to show different slopes of the regression lines and the projected differences over the 24-month observation interval (Δy) and also to demonstrate various probability levels for these lines. From a clinical point of view, the decision to classify a given site as a site with probing attachment loss may

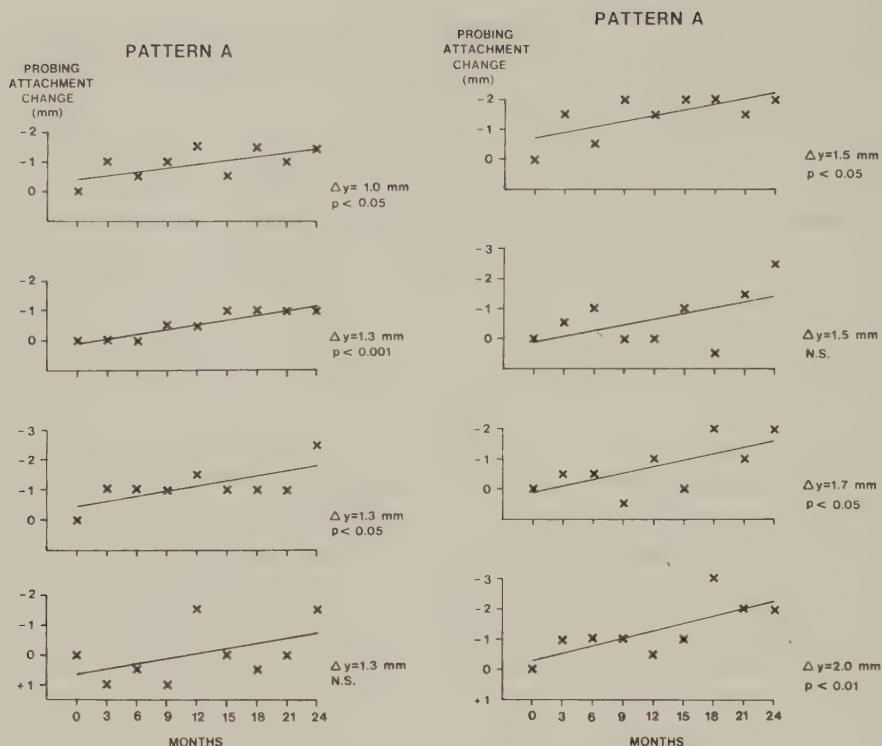


Fig. 9. Examples of linear regression analysis applied to sites with Pattern A probing attachment loss. The projected difference of attachment level over the 24-month observation period (Δy) is given together with the probability level for the slope of the regression line being different from a horizontal line.

need to be based upon the magnitude of the projected difference over the observation interval (Δy) in conjunction with the probability level. The decision of a required minimum for Δy change and a required level of probability may vary and depend upon the purpose of site selection. If sites are being chosen, for example, in an attempt to study them with regard to their clinical-pathological features, a large Δy value and high significance level may be warranted to ensure their validity as deteriorating sites.

Compared to Pattern A (linear change) all other patterns of probing attachment change were relatively infrequent. From the examples of Patterns B, C and D in Figs. 3, 4 and 5 it can be observed that several of the sites with these patterns showed probing attachment level changes approximating a linear pattern. Thus, application of linear regression analysis also for these patterns may be justified. Examples of this application are presented in Figs. 10-12.

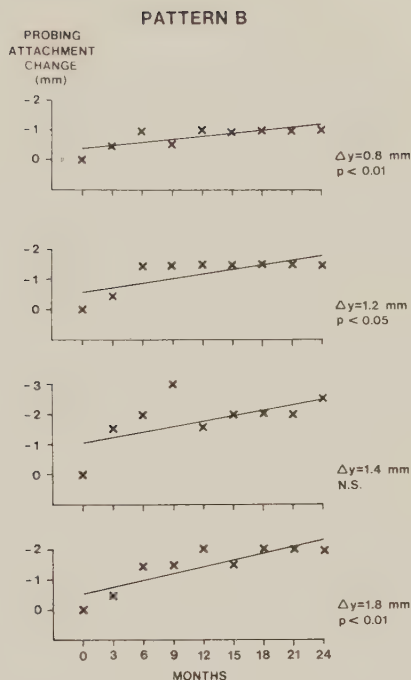


Fig. 10. Examples of linear regression analysis applied to sites with Pattern B probing attachment loss.

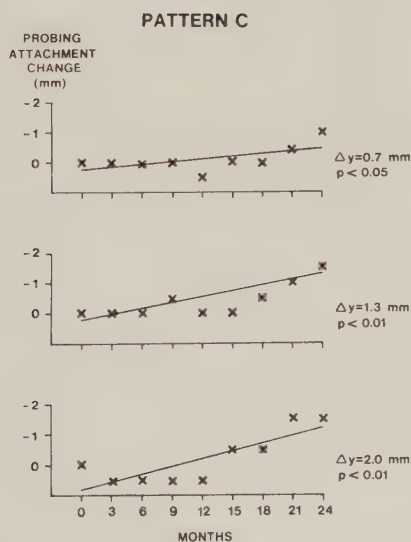


Fig. 11. Examples of linear regression analysis applied to sites with Pattern C probing attachment loss.

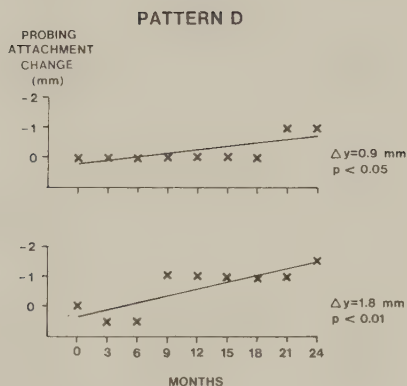


Fig. 12. Examples of linear regression analysis applied to sites with Pattern D probing attachment loss.

Patterns E, F and G did not show a linear component of probing attachment loss and seem unsuitable for evaluation by linear regression analysis. However, for these sites conditions exist that still may speak in favor of application of linear regression. Pattern E has 1 initial recording that deviates from the remaining series of stable measurements. The possibility exists that the single deviant recording is a measurement error rather than a true attachment level recording. Linear regression analysis will be relatively insensitive to a deviation of a single measurement including end point measurements in a series of 9 data points. This "insensitivity" may be desirable in light of the possibility of measurement error in single deviating data points (see examples in Fig. 13.) The undulating changes of patterns F and G may indicate fluctuations in tissue conditions and may warrant a cautious analysis of sites with these patterns. Linear regression analysis will not provide a meaningful magnitude of Δy and a significant probability level in these sites unless a certain number of the data points represents a more apical probing attachment level (see examples in Figs. 14 and 15).

In conclusion, probing attachment loss in sites non-responding to initial periodontal therapy follows a gradual, linear course or approximates a linear pattern for the vast majority of treated sites. For this reason, linear regression analysis seems to be a suitable statistical method for identification of probing attachment loss amongst these sites. This method is theoretically less suitable in non-linear patterns, present in around 15% of sites. The insensitivity of regression analysis in non-linear patterns may be acceptable if a cautious analysis is needed.

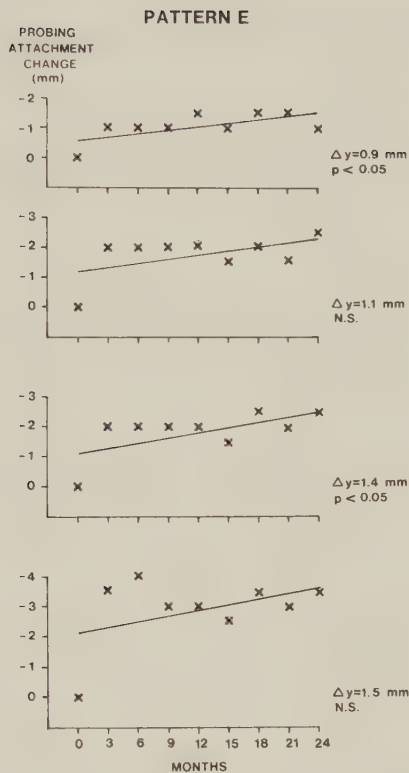


Fig. 13. Examples of linear regression analysis applied to sites with Pattern E probing attachment loss.

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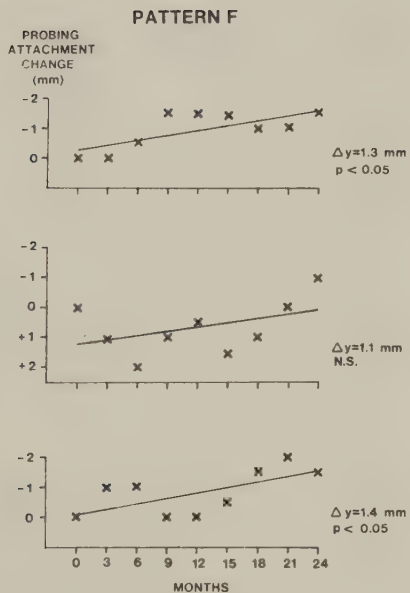


Fig. 14. Examples of linear regression analysis applied to sites with Pattern F probing attachment loss.

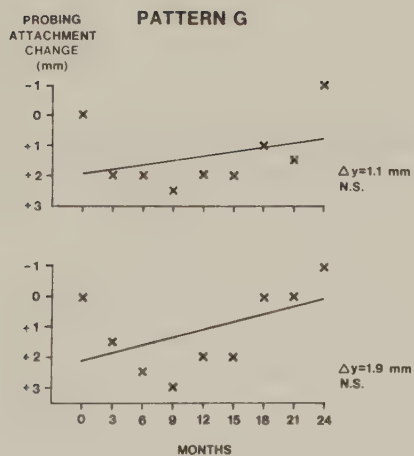


Fig. 15. Examples of linear regression analysis applied to sites with Pattern G probing attachment loss.

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Paper V

EFFECT OF NONSURGICAL PERIODONTAL THERAPY

VI. LOCALIZATION OF SITES WITH
PROBING ATTACHMENT LOSS

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Key words: Probing attachment loss - nonsurgical -
periodontal treatment

Running head: Nonsurgical periodontal therapy

ABSTRACT

Incisors, cuspids and premolars in 49 patients with advanced chronic periodontitis were treated with initial, nonsurgical periodontal therapy. The results were monitored by probing attachment level measurements at 6 sites of each tooth every 3rd month during 24 months. A series of 9 probing attachment level measurements for each site was subjected to linear regression analysis. The slope of the regression line, the projected probing attachment loss during the 24-month interval (Δy) and the probability level of the slope were calculated for each site. 2 groups of sites with probing attachment loss were identified: Group 1: sites with $\Delta y > 1.5$ mm and $p < 0.05$; Group 2: sites with $\Delta y > 1.0$ mm and $p < 0.05$. Group 1 included 120 sites (5%) and Group 2 included 265 sites (10%) of the total of 2532 available sites. In both groups, probing attachment loss was more frequently noticed for sites with an initial probing depth ≤ 3.5 mm than for sites initially ≥ 7.0 mm. The finding that the majority of sites with probing attachment loss was found amongst initially shallow or moderately deep lesions may indicate attachment loss due to trauma associated with therapy rather than loss as a result of a continuing, inflammatory disease process.

INTRODUCTION

In previous studies, the effects of periodontal therapy on probing attachment levels and pocket depths have usually been evaluated from means of recorded measurements. Such means are valuable in determining the overall results. The response to therapy for individual sites, however, may vary. Haffajee et al. (1983a) recommended the use of frequency distributions of different magnitude of probing changes to study the effects of therapy on individual sites.

Improved probing attachment levels are commonly observed after treatment of periodontal pockets. This improvement, however, is not associated with a corresponding gain of connective tissue attachment. The decreased probe penetration seems to be caused by improved tissue tonus and improved adaptation of the junctional epithelium to the tooth (Fowler et al. 1982).

Before therapy, in the presence of inflammation, the probe tip generally penetrates beyond the apical termination of the junctional epithelium and into the subjacent connective tissue (Listgarten 1980, Caton et al. 1981, Jansen et al. 1981, van der Velden & Jansen 1981, Fowler et al. 1982, van der Velden 1982). Therefore, it seems reasonable to assume that a more apical position of the probe tip after therapy compared to the pretherapy level is associated with loss of connective tissue attachment. Data on sites that do not respond to therapy but continue to lose probing attachment may, in contrast to the aforementioned gains, reflect a significant underlying change in connective tissue attachment levels.

The interpretation of periodontal probing is not only complicated by the limitation of the probe tip in disclosing the connective tissue attachment level, but also by the degree of variability of repeated probing measurements. The reproducibility of duplicate recordings may vary by patient, tooth type, tooth surface and by pocket depth (Goodson et al. 1982, Haffajee et al. 1983b, Badersten et al. 1984f). Therefore, in order to determine whether an individual site has lost attachment, the probing reproducibility for that site needs to be considered. Analysis of regression of a series of longitudinal probing attachment measurements for individual sites, as suggested by Goodson et al. (1982), seems to meet this requirement.

In a previous study we found that probing attachment loss in sites non-responsive to initial periodontal therapy follows a gradual, linear course or approximates a linear pattern for the majority of sites. Linear regression analysis seems to be a suitable statistical method for identification of probing attachment loss amongst these sites. For sites with a non-linear

pattern of probing attachment loss this analysis is theoretically less suitable, but may still be justified if a cautious evaluation of attachment loss is warranted (Badersten et al. 1984d).

The purpose of the present investigation was to identify sites with probing attachment loss following initial, nonsurgical periodontal therapy using analysis of regression and to study the localization of these sites.

MATERIAL AND METHODS

The material for the present report originates from 3 previous studies on nonsurgical periodontal therapy (Badersten et al. 1984a, b, c). A total of 49 patients, 34 males and 15 females, 28 to 64 years of age, were available. The incisors, cuspids and premolars in either the maxilla or the mandible were studied. Each patient contributed from 4 to 10 teeth for study. The investigated parts of the dentitions of these patients displayed generalized periodontal destruction involving right and left sides of the mouth to a similar extent. Periodontal pockets at least 5.0 mm deep with calculus and bleeding on probing were present on 2 or more aspects of each tooth.

Therapy

All patients received a combined therapy of oral hygiene instruction and supra- and subgingival debridement. Because of variations in design of the original 3 studies, differences in therapy existed as to:

- 1) start of instrumentation (at baseline or at 3 months)
- 2) number of instrumentations (1 or 3)
- 3) use of instruments (hand or ultrasonic)
- 4) operator for instrumentation (7 different operators)

However, all subgingival instrumentations were completed 9 months after baseline. Additional instruction and reinforcement of supragingival plaque control was provided and teeth polished according to individual needs throughout the 24-month duration of the study.

Methods of measurement

Measurements of probing pocket depth and probing attachment level were recorded at the baseline examination and at every 3rd month by one examiner (author A.B.). Recordings were made at 6 aspects of each tooth: mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual. The measurements were taken to the nearest 0.5 mm. A probe tip 0.5 mm in diameter

and calibrated in 1-mm increments was used. The margins of soft acrylic on-lays provided reference points for the attachment level measurements. A pressure sensitive probe with the probing force standardized to 0.75 N was used for 33 of the subjects. In the remaining subjects a standardized probing force was not used.

The presence of subgingival root furrows, concavities and furcation involvements on proximal root surfaces was recorded at the end of the study by two independent examiners (authors A.B. and R.N.). The records of the two examiners were compared and surfaces, scored positive by one of the examiners only, were reexamined jointly by both examiners. A final decision as to presence or absence of root furrow, concavity and degree of furcation involvement was made. Grade I furcation involvement was scored when a furcation aperture could be identified by probing. Grade II involvement was scored when the furcation could be probed horizontally. Grade III, through-and-through involvement, was not positively identified in any tooth under study.

Presence of proximal intraosseous defects was recorded from initial peri-apical, long cone radiographs. The vertical depth of the defects was measured to the nearest mm from the radiographic bone crest to a point along the root surface, where a periodontal ligament of even radiographic width could be observed. Again, when the measurements of two independent examiners differed, a joint decision was made.

Identification of sites with probing attachment loss

The recordings at 3-month intervals during the 24-month study provided a series of 9 probing attachment level measurements for each site. These measurements were subjected to analysis of regression. The slope of the regression line for each site was calculated as well as the projected probing attachment loss during the 24-month interval (Δy). The probability for each slope being different from a horizontal line was determined using 7 degrees of freedom. From the calculated values of Δy and probability, 2 groups of sites with probing attachment loss were identified based upon the following criteria: Group 1): sites with $\Delta y > 1.5$ mm and $p < 0.05$; Group 2): sites with $\Delta y > 1.0$ mm and $p < 0.05$.

The distribution of these 2 groups of sites with probing attachment loss was studied with respect to patient, tooth type, tooth surface, initial probing pocket depth and presence of root furrow, furcation involvement and intra-osseous defect.

Table 1. Presence of sites with probing attachment loss out of the total number of 2532 available sites as defined by the 2 different criteria

Criteria	Sites with probing attachment loss	
	Number	Percent
Group 1 ($\Delta y > 1.5$ mm, $p < 0.05$)	120	5
Group 2 ($\Delta y > 1.0$ mm, $p < 0.05$)	265	10

Table 2A. Distribution of sites with probing attachment loss by initial probing pocket depth and by tooth surface. Group 1: $\Delta y > 1.5$ mm, $p < 0.05$

Tooth surface	Initial probing pocket depth (mm)							
	≤ 3.5			4.0 - 6.5			≥ 7.0	
	Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss
		Num-ber	Per-cent		Num-ber	Per-cent		Num-ber Per-cent
Buccal	352	39	11	55	4	7	15	1 7
Lingual	119	6	5	239	1	0	64	2 3
Proximal	101	13	13	874	40	5	713	14 2
Total	572	58	10	1168	45	4	792	17 2

RESULTS

The use of $\Delta y > 1.5$ mm and $p < 0.05$ for selection of sites with probing attachment loss (Group 1) yielded 120 sites (5%) out of the total of 2532 available sites. Reducing the required projected loss of attachment to $\Delta y > 1.0$ mm, maintaining $p < 0.05$, generated another 145 sites resulting in 265 sites (10%) in Group 2 (Table 1).

In both groups, probing attachment loss was most frequently noticed for sites with an initial probing depth ≤ 3.5 mm, followed by sites initially 4.0 - 6.5 mm deep. These, in turn, showed higher frequency of loss than sites initially ≥ 7.0 mm deep (Tables 2A and 2B). Overall, buccal tooth surfaces showed a higher incidence of sites with probing attachment loss than proximal and lingual surfaces (Tables 2A and 2B). No particular tooth type showing a higher incidence could be identified (Tables 3A and 3B).

Table 4 presents the number of patients demonstrating different frequencies of sites with probing attachment loss for sites with initial probing pocket depth ≥ 4.0 mm. The majority of patients showed loss at a relatively low

Table 2B. Distribution of sites with probing attachment loss by initial probing pocket depth and by tooth surface. Group 2: $\Delta y > 1.0$ mm, $p < 0.05$

Tooth surface	Initial probing pocket depth (mm)								
	≤ 3.5			4.0 - 6.5			≥ 7.0		
	Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss	
		Num-ber	Per-cent		Num-ber	Per-cent		Num-ber	Per-cent
Buccal	352	89	25	55	7	13	15	1	7
Lingual	119	20	17	239	7	3	64	5	8
Proximal	101	23	23	874	79	9	713	34	5
Total	572	132	23	1168	93	8	792	40	5

Table 3A. Distribution of sites with probing attachment loss by tooth type and tooth surface. Group 1: $\Delta y > 1.5$ mm, $p < 0.05$

Tooth type	Surface								
	Buccal			Lingual			Proximal		
	Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss	
		Num-ber	Per-cent		Num-ber	Per-cent		Num-ber	Per-cent
11/21	72	7	10	72	1	1	288	9	3
12/22	68	4	6	68	1	1	272	6	2
13/23	78	12	15	78	0	0	312	11	4
14/24	66	5	8	66	2	3	264	13	5
15/25	54	9	17	54	0	0	216	15	7
31/41	16	0	0	16	1	6	64	1	2
32/42	14	1	7	14	2	14	56	5	9
33/43	20	3	15	20	1	5	80	3	4
34/44	18	2	11	18	0	0	72	2	3
35/45	16	1	6	16	1	6	64	2	3
Total	422	44	10	422	9	2	1688	67	4

Table 3B. Distribution of sites with probing attachment loss by tooth type and tooth surface. Group 2: $\Delta y > 1.0$ mm, $p < 0.05$

Tooth type	Surface								
	Buccal			Lingual			Proximal		
	Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss		Total number of sites	Sites with probing attachment loss	
		Num-ber	Per-cent		Num-ber	Per-cent		Num-ber	Per-cent
11/21	72	14	19	72	5	7	288	24	8
12/22	68	15	22	68	4	6	272	13	5
13/23	78	28	36	78	4	5	312	18	6
14/24	66	13	20	66	4	6	264	30	11
15/25	54	11	20	54	1	2	216	29	13
31/41	16	2	12	16	4	25	64	3	5
32/42	14	1	7	14	4	29	56	6	11
33/43	20	4	20	20	4	20	80	4	5
34/44	18	3	17	18	1	6	72	4	6
35/45	16	6	37	16	1	6	64	5	8
Total	422	97	23	422	32	8	1688	136	8

proportion of sites.

In both groups, sites at proximal surfaces with root furrows, concavities or furcation involvements showed a higher incidence of probing attachment loss than sites without these characteristics (Table 5). Also, increased depth of radiographic intraosseous defects was associated with more frequent probing attachment loss (Table 6).

DISCUSSION

Linear regression analysis of a series of sequential measurements for the identification of sites with probing attachment loss permits consideration of the magnitude of probing attachment changes and the variability of repeated probing measurements. The magnitude of the changes over the total period of time (Δy) is generated by the slope of the regression line and is determined by the difference on the y axis between the beginning and end points of that line. The variability of the individual measurements about the regression line is considered during calculation of the significance

Table 4. Distribution of subjects by frequency of sites with probing attachment loss for sites with initial probing pocket depth ≥ 4.0 mm. Group 1: $\Delta y > 1.5$ mm, $p < 0.05$; Group 2: $\Delta y > 1.0$ mm, $p < 0.05$

Frequency of probing attachment loss %	Number of subjects	
	Group 1	Group 2
0	24	13
1 - 5	16	12
6 - 10	5	11
11 - 15	1	5
16 - 20	2	6
21 - 25	0	0
26 - 30	1	0
31 - 35	0	2
Total	49	49

Table 5. Distribution of sites with probing attachment loss for proximal surfaces with or without presence of root furrow, concavity or furcation involvement. Results of chi square tests comparing presence of anyone of these features to their absence using 2 x 2 tables

Criteria	Sites with probing attachment loss			
	Group 1		Group 2	
	Number	Percent	Number	Percent
Absence of furrow, concavity or furcation involvement (N=1332)	41	3	85	6
Furrow, concavity (N=206)	16	8	26	13
Furcation, grade I (N=86)	4	5	12	14
Furcation, grade II (N=64)	6	9	13	20
$\chi^2 = 12.1$ $p < 0.001$		$\chi^2 = 22.9$ $p < 0.001$		

Table 6. Distribution of sites with probing attachment loss for proximal surfaces with or without radiographic intraosseous defects and results of chi square tests (2 x 4 tables)

Depth of radiographic intraosseous defect (mm)	Group 1		Group 2	
	Number	Percent	Number	Percent
0 (N=1118)	38	3	82	7
1 - 2 (N=256)	10	4	21	8
3 - 4 (N=232)	11	5	22	9
≥5 (N=82)	8	10	11	13
$\chi^2 = 8.5$ $p < 0.05$		$\chi^2 = 4.6$ N.S.		

level of the slope. For the purpose of this study 2 groups of sites with probing attachment loss were identified: for Group 1, $\Delta y > 1.5$ mm was required; for Group 2, $\Delta y > 1.0$ mm only was required. For both groups a significance level of $p < 0.05$ had to be satisfied. The selection of these criteria for Groups 1 and 2 was somewhat arbitrary, but was made after repeated studies of scatter diagrams of measurements from sites with different magnitude of Δy and different levels of significance. It is probable, that the vast majority of the 120 sites in Group 1 warrants to be classified as "losers". The magnitude of the projected attachment level difference ($\Delta y > 1.5$ mm) together with the limited variability of the measurements ($p < 0.05$) makes it reasonable to assume, that these sites display loss of connective tissue attachment. Because of the lower magnitude of Δy for sites included in Group 2, the clinical significance and certainty of attachment loss in these sites may be more questionable. Nevertheless, Group 2 was included to offer a larger group of sites and to supplement the study of sites in Group 1.

A high proportion of sites with probing attachment loss in both groups was observed for sites with shallow initial probing depth. This finding is in agreement with previous studies, reporting mean loss of probing attachment for shallow sites following nonsurgical therapy (Badersten et al. 1981, 1984a, b, c, Hill et al. 1981, Isidor 1981, Lindhe et al. 1982a, b, Pihlstrom et al. 1983). Shallow sites with probing attachment loss were noted for buccal, lingual and proximal tooth surfaces. This attachment loss may be caused by trauma from instrumentation during the initial phase of therapy, as the study of scatter diagrams of probing attachment changes in some of these sites disclosed an initial loss of probing attachment followed by a stabilization of the probing levels during the remaining observation interval (Badersten et al. 1984d). Scatter diagrams from other shallow sites with probing attachment loss, however, indicated a slight but gradual loss of attachment throughout the entire 24-month period that seemingly could not be accounted for by instrumentation injury. Vigorous tooth cleaning procedures may possibly explain this attachment loss.

The limited proportion of sites with probing attachment loss in pockets initially 7.0 mm or deeper indicates that progression of disease can be prevented by nonsurgical therapy in the vast majority of these sites. It needs to be stressed, however, that measurements for molar teeth are not included in this study.

The number of shallow sites per subject was too small to determine if some patients were more prone to probing attachment loss in these sites than other

patients. Study of sites initially 4.0 mm or deeper revealed little variation between the subjects. Most patients showed a limited number of sites with probing attachment loss. A few patients, however, seemed more unresponsive to the therapy and demonstrated a higher proportion of sites with attachment loss.

The incidence of sites with probing attachment loss was slightly higher for proximal surfaces with root furrows, concavities or furcation involvements than for surfaces without these characteristics. Presence of furrow, concavity or furcation involvement may make the debridement of these sites more difficult. It is also conceivable that the posttreatment adaptation of the gingiva to the root surface is compromised by the presence of these features, which may facilitate microbial repopulation subgingivally. Long term surveys of tooth loss in treated periodontal patients indicate that furcated teeth may have a less favorable prognosis (Hirschfeld & Wasserman 1978, McFall 1982).

The incidence of sites with probing attachment loss was also slightly higher for proximal surfaces with radiographic intraosseous defects than for surfaces without osseous defects. Deeper pockets associated with intraosseous defects may be more difficult to debride and may also be prone to subgingival repopulation.

The fact that the vast majority of the sites with probing attachment loss is found among initially shallow or moderately deep lesions raises the question to what extent loss of probing attachment following initial, nonsurgical therapy is caused by a continuing, inflammatory disease process. For initially shallow sites, trauma from instrumentation and tooth cleaning procedures offer the most plausible explanation. For deeper sites, a continuing disease process needs to be considered. Further analyses of these sites, particularly with respect to clinical signs of inflammation, have been performed and are presented in a subsequent publication (Badersten et al. 1984e).

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Paper VI

EFFECT OF NONSURGICAL PERIODONTAL THERAPY

VII. BLEEDING, SUPPURATION AND
PROBING DEPTH IN SITES WITH
PROBING ATTACHMENT LOSS

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Key words: Probing attachment loss - bleeding -
suppuration - probing depth - nonsurgical -
periodontal treatment

Running head: Nonsurgical periodontal therapy

ABSTRACT

Incisors, cuspids and premolars in 49 patients with advanced chronic periodontitis were treated with initial, nonsurgical periodontal therapy. The results were monitored by probing attachment level measurements for 6 sites of each tooth every 3rd month during 24 months. Amongst sites with initial probing depth ≥ 4.0 mm, sites with probing attachment loss were identified using regression analysis. Scores for plaque, bleeding, suppuration on probing and probing depth, obtained for these sites during the 24-month study, were analyzed to determine if any of the scores could be used diagnostically as an indicator of probing attachment loss. Diagnostic sensitivity and predictability was calculated for different levels of each of the scores. The results showed that sites with probing attachment loss were more frequent for sites with high scores for plaque, bleeding, residual probing depth and suppuration than in sites with low scores. However, the diagnostic sensitivity and predictability of these clinical indicators was generally low. Thus, records of plaque, bleeding, suppuration and probing depth do not obviate the need for probing attachment level measurements for identification of sites with probing attachment loss following initial, nonsurgical periodontal therapy.

INTRODUCTION

Bleeding upon probing, suppuration and pocket depth are clinical signs used to facilitate diagnosis of periodontal disease and to evaluate the need for periodontal therapy. The results of Haffajee et al. (1983b), however, seem to question the diagnostic reliability of these criteria. They monitored untreated patients every 2 months during 1 year and found that none of the criteria studied was a reliable predictor of loss of probing attachment. They concluded that although these criteria may provide information as to the extent of previous disease and the current condition of the tissues, they cannot be used as predictors of destructive disease activity.

Periodontal patients are usually subjected to a period of initial therapy consisting of oral hygiene instruction and supra- and subgingival debridement. Reevaluation at the end of this phase is performed to determine the need for supplementary therapy, often surgical in nature. At the time of reevaluation, bleeding upon probing, suppuration upon probing and residual probing depth are often used as indicators of the response to initial therapy. The present study was performed to evaluate to what extent these criteria indicate lack of response to initial therapy as demonstrated by continuing loss of probing attachment.

MATERIAL AND METHODS

The material for the present report originates from 3 previous studies on nonsurgical periodontal therapy (Badersten et al. 1984a, b, c). A total of 49 patients, 34 males and 15 females, 28 to 64 years of age, were available. The incisors, cuspids and premolars in either the maxilla or the mandible were studied. Each patient contributed from 4 to 10 teeth for study. The investigated parts of the dentitions of these patients displayed generalized periodontal destruction involving right and left sides of the mouth to a similar extent. Periodontal pockets at least 5.0 mm deep with calculus and bleeding on probing were present on 2 or more aspects of each tooth.

Therapy

All patients received a combined therapy of oral hygiene instruction and supra- and subgingival debridement. Because of variations in design of the original 3 studies, differences in therapy existed as to:

- 1) start of instrumentation (at baseline or at 3 months)
- 2) number of instrumentations (1 or 3)
- 3) use of instruments (hand or ultrasonic)
- 4) operator for instrumentation (7 different operators)

However, all subgingival instrumentations were completed 9 months after baseline. Additional instruction and reinforcement of supragingival plaque control was provided and teeth polished according to individual needs throughout the 24-month duration of the study.

Methods of measurement

Measurements of dental plaque, bleeding on probing, probing pocket depth and probing attachment level were recorded at the baseline examination and at every 3rd month by one examiner (author A.B.). Recordings were made at 6 aspects of each tooth: mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual.

Probing pocket and probing attachment measurements were recorded after the plaque and bleeding scores. Bleeding on probing as well as probing pocket and probing attachment measurements were performed with a pressure sensitive probe set at a probing force of 0.75 N in 33 subjects. In the remaining subjects, a standardized probing force was not used. Probing pocket and probing attachment measurements were taken to the nearest of 0.5 mm. A probe tip 0.5 mm in diameter and calibrated in 1-mm increments was used. The margins of soft acrylic onlays provided reference points for the attachment level measurements.

Suppuration on probing was recorded at 18 and 24 months. A droplet of pus visible either after the probing for bleeding examination or after the subsequent probings for pocket depth and attachment level yielded a positive score.

Scores of plaque and bleeding frequencies were calculated for each site by adding the number of examinations throughout the 24-month period (9 possible) that showed presence of plaque and bleeding upon probing.

Identification of sites with probing attachment loss

The recordings at 3-month intervals during the 24-month study provided a series of 9 probing attachment level measurements for each site. These measurements were subjected to linear analysis of regression. Only sites with initial probing pocket depth ≥ 4.0 mm were included. The slope of the regression line for each of these sites was calculated together with the projected prob-

ing attachment loss during the 24-month interval (Δy). The probability for each slope being different from a horizontal line was determined using 7 degrees of freedom. From the Δy values and probabilities, 2 groups of sites with probing attachment loss were identified based upon the following criteria: 1) sites with $\Delta y > 1.5$ mm and $p < 0.05$; 2) sites with $\Delta y > 1.0$ mm and $p < 0.05$.

Determination of diagnostic sensitivity and predictability

The reliability of scores for plaque, bleeding, suppuration and probing depth in identifying sites with probing attachment loss was evaluated from calculations of diagnostic sensitivity and predictability ratios in percent as follows:

Score	Probing attachment loss	
	Presence	Absence
Positive	a	b
Negative	c	d

$$\text{Diagnostic sensitivity} = \frac{a}{a+c}$$

$$\text{Diagnostic predictability} = \frac{a}{a+b}$$

Thus, diagnostic sensitivity expresses the proportion of sites with attachment loss that shows a positive score (true positive ratio). Diagnostic predictability gives the proportion of sites with positive scores that shows loss of probing attachment. Both sensitivity and predictability should approach 100% for reliable tests.

RESULTS

The use of $\Delta y > 1.5$ mm and $p < 0.05$ for selection of sites with probing attachment loss (Group 1) yielded 62 sites (3%) out of the total of 1960 available sites with initial probing pocket depth ≥ 4.0 mm. Reducing the required projected loss of attachment to $\Delta y > 1.0$ mm, maintaining $p < 0.05$, generated another 71 sites resulting in 133 sites (7%) in Group 2.

Table 1. Sensitivity and predictability values in percent for plaque frequency scores of different magnitude. Group 1: $\Delta y > 1.5$ mm, $p < 0.05$; Group 2: $\Delta y > 1.0$ mm, $p < 0.05$. N = number of available surfaces

Plaque frequency	Group 1 (N=62)		Group 2 (N=133)	
	Sensi-tivity	Predict-ability	Sensi-tivity	Predict-ability
≥ 5 (N=161)	11	4	9	8
≥ 6 (N=99)	7	4	5	7
≥ 7 (N=55)	5	6	2	6
≥ 8 (N=25)	5	12	2	12
9 (N=8)	3	25	2	25

The results showed that plaque, bleeding and magnitude of residual probing depth at 24 months were all associated with probing attachment loss. This association was demonstrated by increased diagnostic predictability along with increased frequency scores for plaque and bleeding and with deeper residual probing depth for both groups of sites with probing attachment loss (Tables 1-3). However, the association was weak as evidenced by the low diagnostic sensitivity and predictability for all three criteria. For example, in the material there were 96 sites available that displayed bleeding at 7 or more examinations. The predictability and sensitivity for this frequency of bleeding at these sites were around 25% in both groups (Table 2). Thus, only 25% of the sites with probing attachment loss showed bleeding this often and only 25% of the sites with this bleeding frequency showed probing attachment loss. Similarly, there were 90 sites available that showed a residual probing depth of 7.0 mm or more. The sensitivity and predictability for this magnitude of residual probing depth ranged between 27-40% (Table 3).

Suppuration on probing was associated with probing attachment loss as evidenced by higher diagnostic predictability for suppuration at both the 18- and 24-month examinations compared to suppuration at 1 of these examinations only (Table 4). This association was weak as revealed by the low sensitivity and predictability values. There were 97 sites available that showed suppuration at 18 or 24 months with sensitivity and predictability ranging from 17% to 30%.

Table 2. Sensitivity and predictability values in percent for bleeding frequency scores of different magnitude

Bleeding frequency	Group 1 (N=62)		Group 2 (N=133)	
	Sensitivity	Predictability	Sensitivity	Predictability
≥ 5 (N=335)	47	9	35	14
≥ 6 (N=186)	40	13	29	20
≥ 7 (N=96)	29	23	20	28
≥ 8 (N=34)	11	21	8	32
9 (N=12)	3	17	3	33

Table 3. Sensitivity and predictability values in percent for residual probing depths of different magnitude at 24 months

Residual probing depth (mm)	Group 1 (N=62)		Group 2 (N=133)	
	Sensitivity	Predictability	Sensitivity	Predictability
≥ 5.0 (N=577)	76	8	66	15
≥ 6.0 (N=269)	65	15	49	24
≥ 7.0 (N=90)	39	27	27	40
≥ 8.0 (N=30)	15	30	11	47

Table 4. Sensitivity and predictability values in percent for suppuration

Suppuration	Group 1 (N=62)		Group 2 (N=133)	
	Sensi- tivity	Predict- ability	Sensi- tivity	Predict- ability
At 18 months (N=59)	19	20	17	22
At 24 months (N=58)	16	17	21	28
At 18 <u>or</u> 24 months (N=97)	26	17	22	30
At 18 <u>and</u> 24 months (N=20)	10	30	10	40

Combinations of the 3 criteria: bleeding frequency ≥ 7 , residual probing depth ≥ 7.0 mm and suppuration at 18 or 24 months, improved the predictability to around 50% but resulted in low sensitivity (Table 5).

Around 60% of sites that showed an increase in probing depth of 1.0 mm or more at 24 months compared to baseline had lost probing attachment. The majority of sites with attachment loss, however, did not demonstrate increase in probing depth (Table 6). Combinations of increase in probing depth with bleeding frequency ≥ 7 , residual probing depth ≥ 7.0 mm or suppuration at 18 or 24 months did not improve predictability but lowered the sensitivity markedly (Table 7).

The relationship between probing attachment loss calculated from recordings at 24 months minus baseline recordings versus calculation with regression analysis is presented in Table 8. Almost all sites with attachment loss established by regression analysis demonstrated a loss of probing attachment of 1.0 mm or more at 24 months compared to baseline. However, the predictability value of ≥ 1.0 mm probing attachment loss at 24 months was less than 50%.

Probing attachment loss of 1.5 mm or more at 24 months compared to baseline reached both sensitivity and predictability values to between 60-70% (Table 8). Combinations of this amount of attachment level difference with bleeding

Table 5. Sensitivity and predictability values in percent for combinations of bleeding frequency ≥ 7 , residual probing depth ≥ 7.0 mm and suppuration at 18 or 24 months

Combination of tests	Group 1 (N=62)		Group 2 (N=133)	
	Sensi- tivity	Predict- ability	Sensi- tivity	Predict- ability
Bleeding frequency ≥ 7 Residual probing depth ≥ 7.0 mm (N=23)	18	48	10	57
Bleeding frequency ≥ 7 Residual probing depth ≥ 7.0 mm Suppuration at 18 or 24 months (N=15)	13	53	8	67

Table 6. Sensitivity and predictability values in percent for different magnitude of increase in probing depth at 24 months compared to baseline

Increase in probing depth 0-24 months (mm)	Group 1 (N=62)		Group 2 (N=133)	
	Sensi- tivity	Predict- ability	Sensi- tivity	Predict- ability
≥ 0.5 (N=77)	48	39	30	52
≥ 1.0 (N=36)	32	56	18	67
≥ 1.5 (N=16)	19	75	10	81
≥ 2.0 (N=10)	15	90	7	90

Table 7. Sensitivity and predictability values in percent for combinations of increase in probing pocket depth ≥ 0.5 mm with bleeding frequency ≥ 7 , residual probing depth ≥ 7.0 mm and suppuration at 18 or 24 months

Combination of tests	Group 1 (N=62)		Group 2 (N=133)	
	Sensi- tivity	Predict- ability	Sensi- tivity	Predict- ability
Increase in probing depth ≥ 0.5 mm Bleeding frequency ≥ 7 (N=18)	0	39	0	28
Increase in probing depth ≥ 0.5 mm Residual probing depth ≥ 7.0 mm (N=27)	1	41	0	26
Increase in probing depth ≥ 0.5 mm Suppuration at 18 or 24 months (N=16)	0	44	0	25

Table 8. Sensitivity and predictability values in percent for different magnitude of loss of probing attachment at 24 months compared to baseline

Loss of probing attachment 0-24 months (mm)	Group 1 (N=62)		Group 2 (N=133)	
	Sensi- tivity	Predict- ability	Sensi- tivity	Predict- ability
≥ 1.0 (N=271)	100	23	93	46
≥ 1.5 (N=126)	89	44	68	71
≥ 2.0 (N=60)	63	65	34	75
≥ 2.5 (N=31)	32	65	17	71
≥ 3.0 (N=15)	8	73	18	73

Table 9. Sensitivity and predictability values in percent for combinations of loss of probing attachment ≥ 1.5 mm with bleeding frequency ≥ 7 , residual probing depth ≥ 7.0 mm and suppuration at 18 or 24 months

Combination of tests	Group 1 (N=62)		Group 2 (N=133)	
	Sensi- tivity	Predict- ability	Sensi- tivity	Predict- ability
Loss of probing attachment ≥ 1.5 mm Bleeding frequency ≥ 7 (N=27)	24	56	15	74
Loss of probing attachment ≥ 1.5 mm Residual probing depth ≥ 7.0 mm (N=35)	32	57	22	83
Loss of probing attachment ≥ 1.5 mm Suppuration at 18 or 24 months (N=26)	23	54	18	92

frequency ≥ 7 , residual probing depth ≥ 7.0 mm or suppuration at 18 or 24 months did not improve the predictability but lowered the sensitivity to 15-30% (Table 9).

DISCUSSION

The diagnostic value of various clinical scores to identify sites with probing attachment loss following initial, nonsurgical periodontal therapy was evaluated in the present study. The statistical method selected for determination of sites with probing attachment loss becomes critical for this evaluation. Haffajee et al. (1983a) compared 3 different methods and observed advantages and limitations with each method. We selected linear regression analysis because of the following reasons: 1) in a previous study we observed that the majority of sites non-responsive to initial therapy shows a gradual, linear pattern of probing attachment loss or a course of attachment loss approximating a linear pattern (Badersten et al. 1984d); 2) the relative insensitivity of linear regression analysis in non-linear patterns would be acceptable for the purpose of this study since a cautious determination of

probing attachment loss would be of no disadvantage.

In this study as well as in a previous study (Badersten et al. 1984e), we selected 2 groups of sites with probing attachment loss: Group 1 having a Δy magnitude of >1.5 mm and Group 2 a Δy magnitude of >1.0 mm. For inclusion in either group, a significance level of $p < 0.05$ had to be satisfied. The selection of these criteria for Groups 1 and 2 was somewhat arbitrary, but was made after repeated studies of scatter diagrams of probing attachment recordings from sites with different magnitude of Δy and different levels of significance. It is probable that the vast majority of the 62 sites in Group 1 warrants to be classified as "losers". The magnitude of the projected attachment level difference ($\Delta y > 1.5$ mm) together with the limited variability of the measurements ($p < 0.05$) makes it reasonable to assume that these sites display loss of connective tissue attachment. Because of the lower level of Δy for sites included in Group 2, the clinical significance and certainty of attachment loss in these sites may be questionable. Nevertheless, Group 2 was included to offer a larger group of sites and to supplement the study of sites in Group 1.

Sites with probing attachment loss having initial probing depth ≤ 3.5 mm were excluded from analysis. Attachment loss in these sites following non-surgical therapy may be related to trauma from instrumentation or to vigorous tooth cleaning rather than being caused by microbial agents (Badersten et al. 1984e). Limitation of the investigated sites to those with initial probing pocket depth of 4.0 mm or more would seem to favor the diagnostic outcome of the clinical criteria under study.

The results of the study show that presence of plaque, bleeding on probing, suppuration on probing and magnitude of residual probing depth were all associated with probing attachment loss. Sites with either high plaque scores, high bleeding scores, suppuration or deep residual probing depths showed probing attachment loss more often than sites with low scores. However, the predictability value of any one of these recordings did not exceed 30-40%. In other words, the probability of identifying a deteriorating site using any of the above recordings alone is, at best, 1 out of 3. The predictability could be improved by a combination of high scores of the above criteria. Thus, the probability of identifying a deteriorating site is increased to 1 out of 2 by a combination of a bleeding frequency ≥ 7 , a residual probing depth ≥ 7.0 mm and suppuration.

An increase in probing depth following therapy yielded high predictability values. Around 60% of sites with ≥ 1.0 mm increase in probing depth at 24

months compared to baseline showed probing attachment loss. The corresponding predictability was 80% for sites with ≥ 1.5 mm increase and 90% for sites with ≥ 2.0 mm increase in probing depth. This would seem to indicate that increase in probing depth following initial therapy could be used as a criterion to identify non-responding sites with continuing probing attachment loss and obviate more demanding and time consuming probing attachment level measurements. However, our results demonstrate that the diagnostic sensitivity for increase in probing depth is low. Only 30% or less of sites with probing attachment loss show increase in probing depth ≥ 1.0 mm. Combinations of increase in probing depth with high scores for bleeding, residual probing depth and suppuration did not seem to increase the predictability and markedly lowered the sensitivity.

As expected, attachment loss calculated from recordings at 24 months minus baseline recordings showed favorable diagnostic sensitivity and predictability for attachment loss calculated by regression analysis. A loss of attachment of ≥ 1.5 mm at 24 months compared to baseline demonstrated both sensitivity and predictability of around 70% for Group 2 ($\Delta y > 1.0$ mm, $p < 0.05$). Similarly, loss of attachment of ≥ 2.0 mm at 24 months compared to baseline yielded sensitivity and predictability values of around 65% for Group 1 ($\Delta y > 1.5$ mm, $p < 0.05$). Combinations of attachment loss at 24 months compared to baseline with high scores for bleeding on probing, residual probing depth or suppuration did not seem to improve predictability any further and markedly lowered sensitivity.

In a previous study we observed that the vast majority of sites with probing attachment loss following initial, nonsurgical therapy is found among initially shallow or moderately deep lesions. Relatively few sites with deep initial pocket depths showed attachment loss (Badersten et al. 1984e). This led us to raise the question to what extent probing attachment loss following initial therapy is caused by an ongoing inflammatory process. In the present study it is observed that the majority of sites with probing attachment loss does not demonstrate high bleeding scores, suppuration or deep residual probing depths, in spite of the fact that the analysis has been limited to sites with initial pocket depths ≥ 4.0 mm. This would seem to be another reason to question the importance of the inflammatory component in the etiology of the probing attachment loss following initial therapy. For shallow sites, primarily located on buccal tooth surfaces, trauma from instrumentation or tooth cleaning may be a causative factor (Badersten et al. 1984e). Trauma from instrumentation is also conceivable in deeper pockets. However, the attachment loss in the majority of deeper pockets, when it occurs, is observed gradual-

ly throughout the 24 months of observation, in spite of the fact that instrumentation has been performed at baseline time point only (Badersten et al. 1984d). This speaks against instrumentation as a cause in deeper pockets. Trauma from tooth cleaning appears less likely to cause probing attachment loss in deeper sites than in shallower sites, because the marginal tissues are more remote from the connective tissue attachment level. Thus, it appears that microbial or other agents may cause attachment loss without producing an inflammatory response that can readily be observed clinically.

The results of the present study confirmed the results by Haffajee et al. (1983b) that clinical evaluations of bleeding on probing, suppuration or probing pocket depth can not be used to determine deterioration of periodontal probing attachment levels. Persistent bleeding, suppuration and deep probing depths following initial, nonsurgical periodontal therapy would seem to indicate that the therapy was ineffective in erradicating inflammation of these tissues. However, the persistence of these clinical signs of inflammation seems to have limited bearing on attachment loss within a time frame of 24 months. These findings should not be used to justify neglect of continuous bleeding, suppuration or deep residual probing depths following therapy. Given longer observation intervals persistence of these criteria may be indicative of probing attachment loss. Nevertheless, the findings of this study justify a cautious interpretation of clinical findings at reevaluation following initial therapy. Also, a therapist who elects to institute supplementary surgical therapy following reevaluation based upon clinical signs of bleeding, suppuration and deep residual probing depths should be aware that he may be treating residual symptoms of the disease rather than the disease itself. Finally, the findings of the present study demonstrate that records of bleeding, suppuration and probing depths can not substitute for probing attachment level measurements.

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